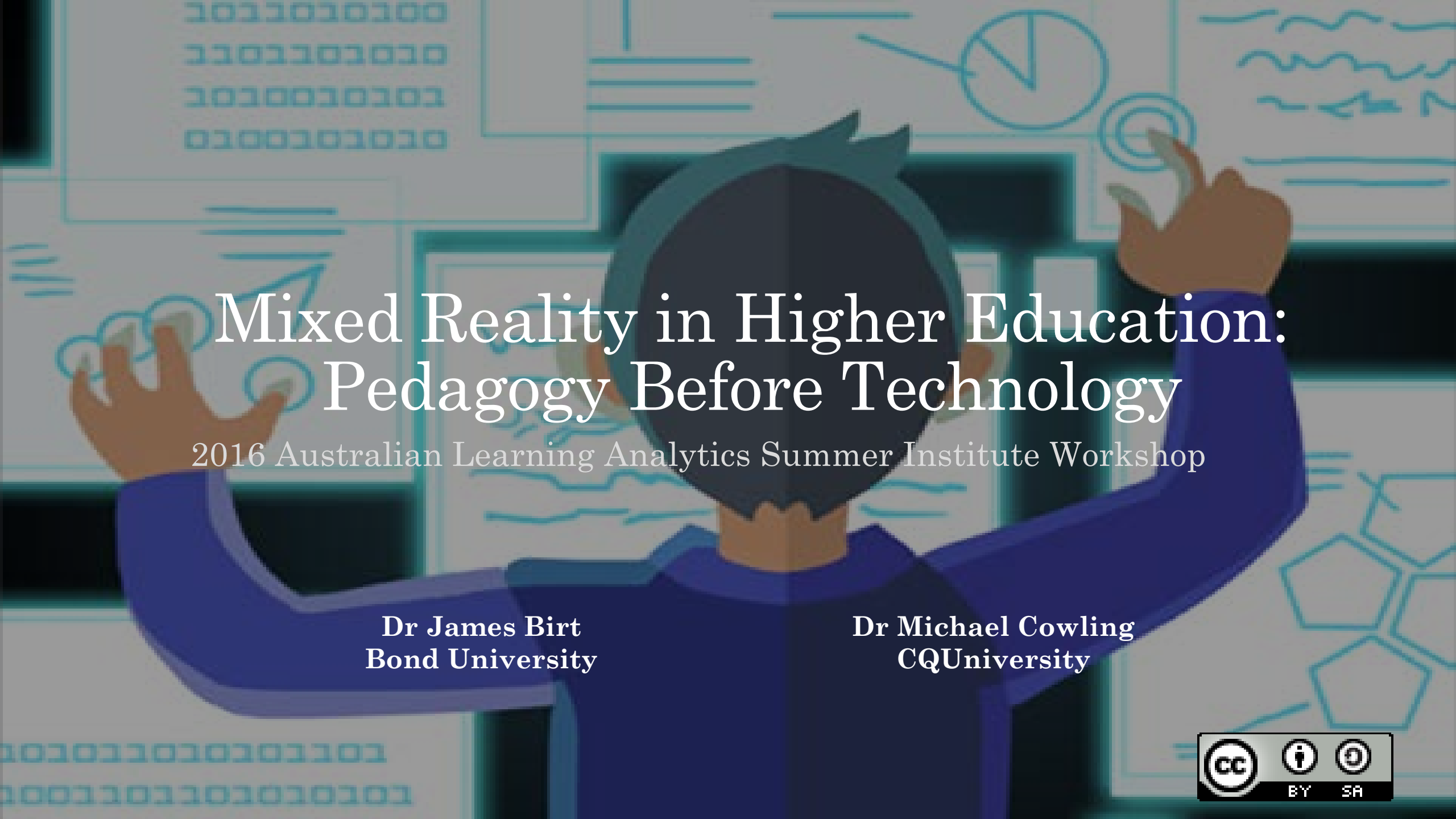
Mixed reality in higher education: Pedagogy before technology

Birt, James R.; Cowling, Michael A



Mixed Reality in Higher Education: Pedagogy Before Technology

2016 Australian Learning Analytics Summer Institute Workshop

Dr James Birt
Bond University

Dr Michael Cowling
CQUniversity

Mixed Reality in Higher Education: Workshop Summary

Topic	Duration (minutes)
Welcome, introductions & housekeeping	5
Future Proof: future jobs, skills & why mixed reality	15
Mixed reality hands on: featuring three (3) case studies	25
Break	5
Heart MR: simulation + learning analytics breakdown	30
Pedagogy before technology & lessons learned	10
Concept mapping a mixed reality pedagogy pilot study – from learning outcomes to applied simulation	25
Workshop conclusion & feedback survey	5

www.bond.edu.au/profile/dr-james-birt

Technology just part of the class

ADOPTING technology in the classroom should just be a part of the learning process, an academic from Queensland's CQUniversity says.

Dr Michael Cowling has written a report on technology, which he will present this week in Adelaide, suggesting it was better to stop thinking about technology as an enhancement or a distraction and for teachers to view it as just part of the classroom.

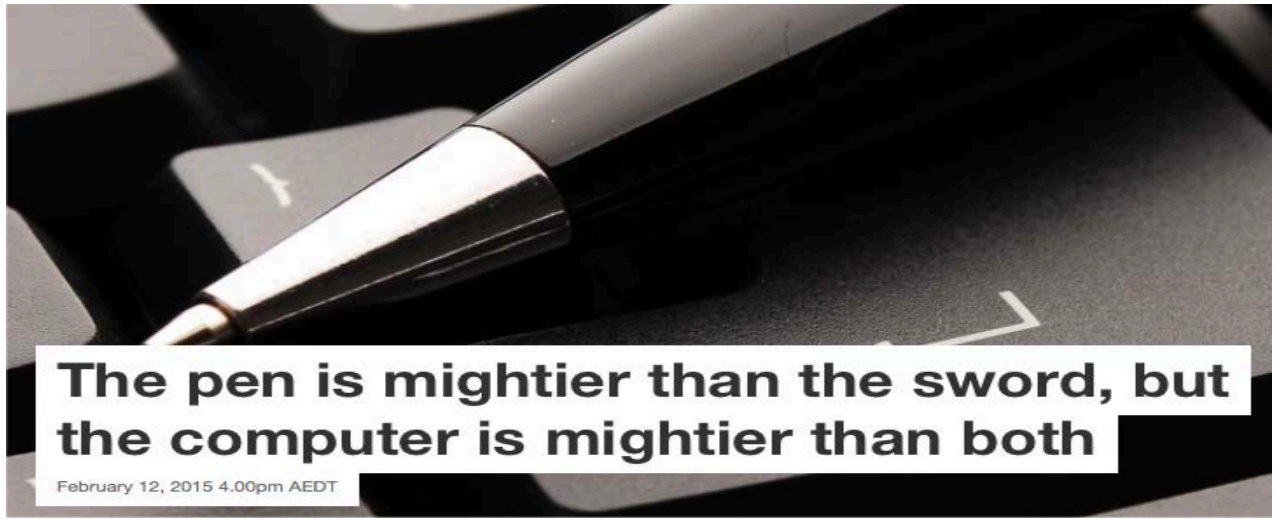
He said this was particularly important as technology became more a part of students' lives, with one study indicating a "near ubiquitous" level of access to mobile phones or computers, and another showing 86 per cent of students preferred using the internet to finding information, rather than looking in a book.

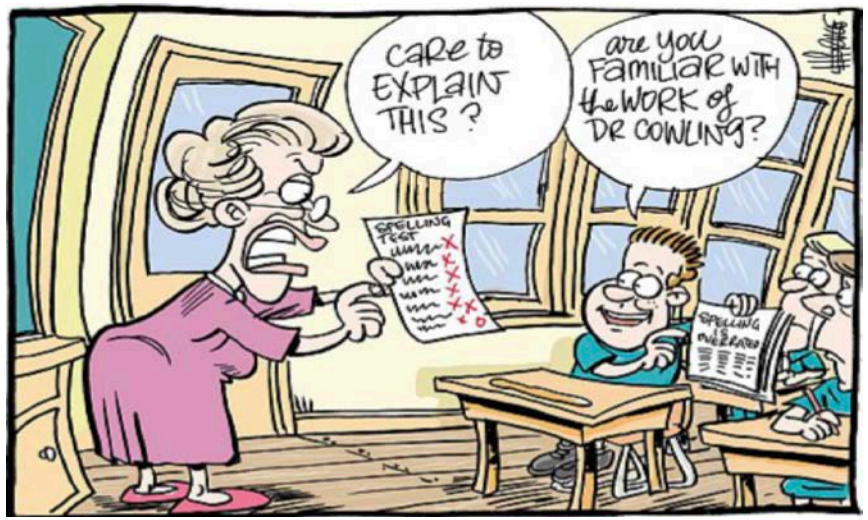
"When we all adopted whiteboards instead of chalkboards or digital projectors instead of overhead projectors, we didn't spend 10 years talking about a 'whiteboard-led classroom' or a 'projector-enabled classroom'," he said. Dr Cowling said the trend towards a technology-led pedagogy needed to be replaced instead with pedagogy-led technology.

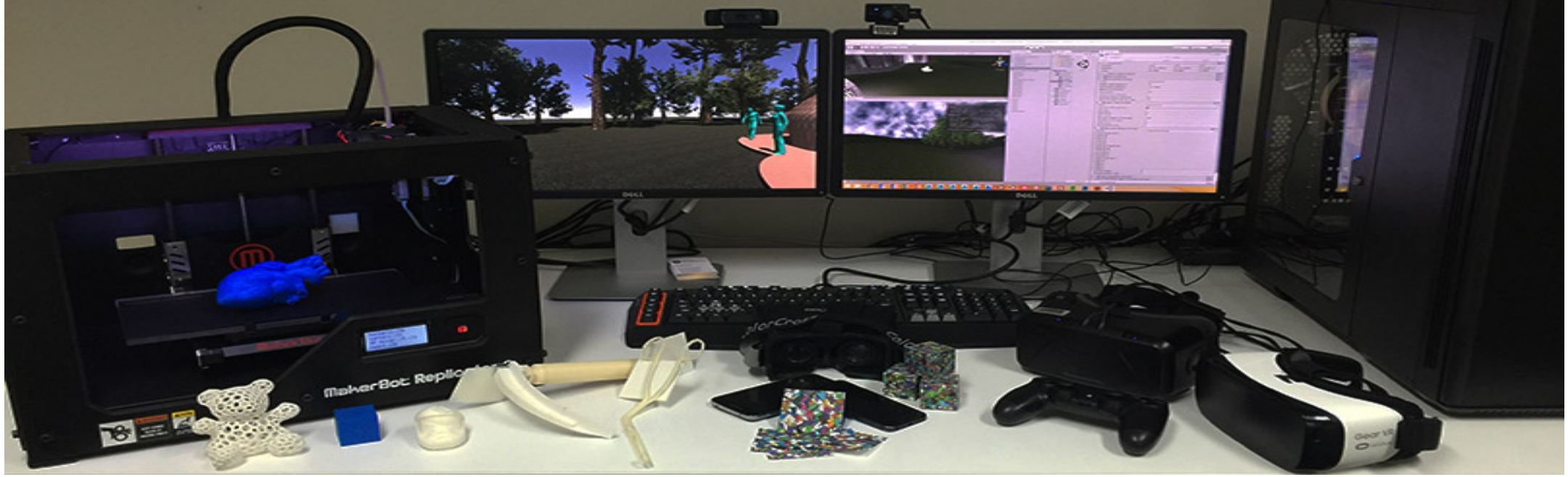
This acknowledged that learning was the most important part of education.

Dr Michael Cowling will present his paper at the International Education Association and Australia New Zealand Student Services Association joint conference at the Hilton Adelaide from today until Friday.

www.michaelacowling.com







www.mixedrealityresearch.com

Spatial Design

Paramedics Skills

Anatomy Education

Network Modeling

Merging physical and virtual worlds through virtual reality, augmented reality, 3d printing & game technology

FUTUREPROOF

The Future of Jobs

- 4th Industrial Revolution
- Developments in AI, robotics, visualization, nanotechnology, 3-D printing, genetics & biotechnology
- Widespread disruption to business & labour markets worldwide – automation + technology
- 40% of current jobs gone in 10 years → primary disruption white collar jobs!

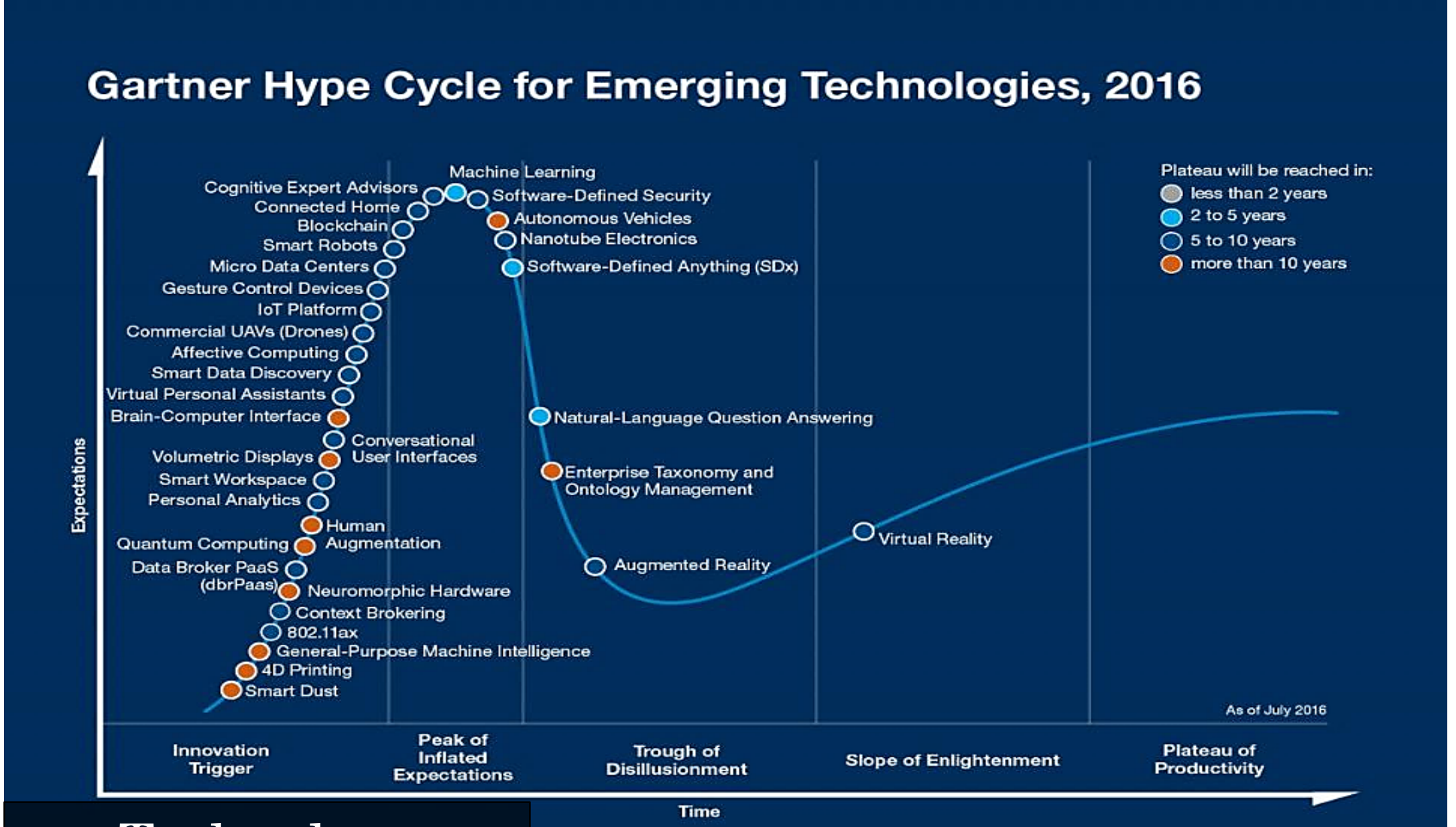
Watch Future Proof – Four Corners ABC

Tomorrows Digitally Enabled Workforce

The industrial revolution's next wave

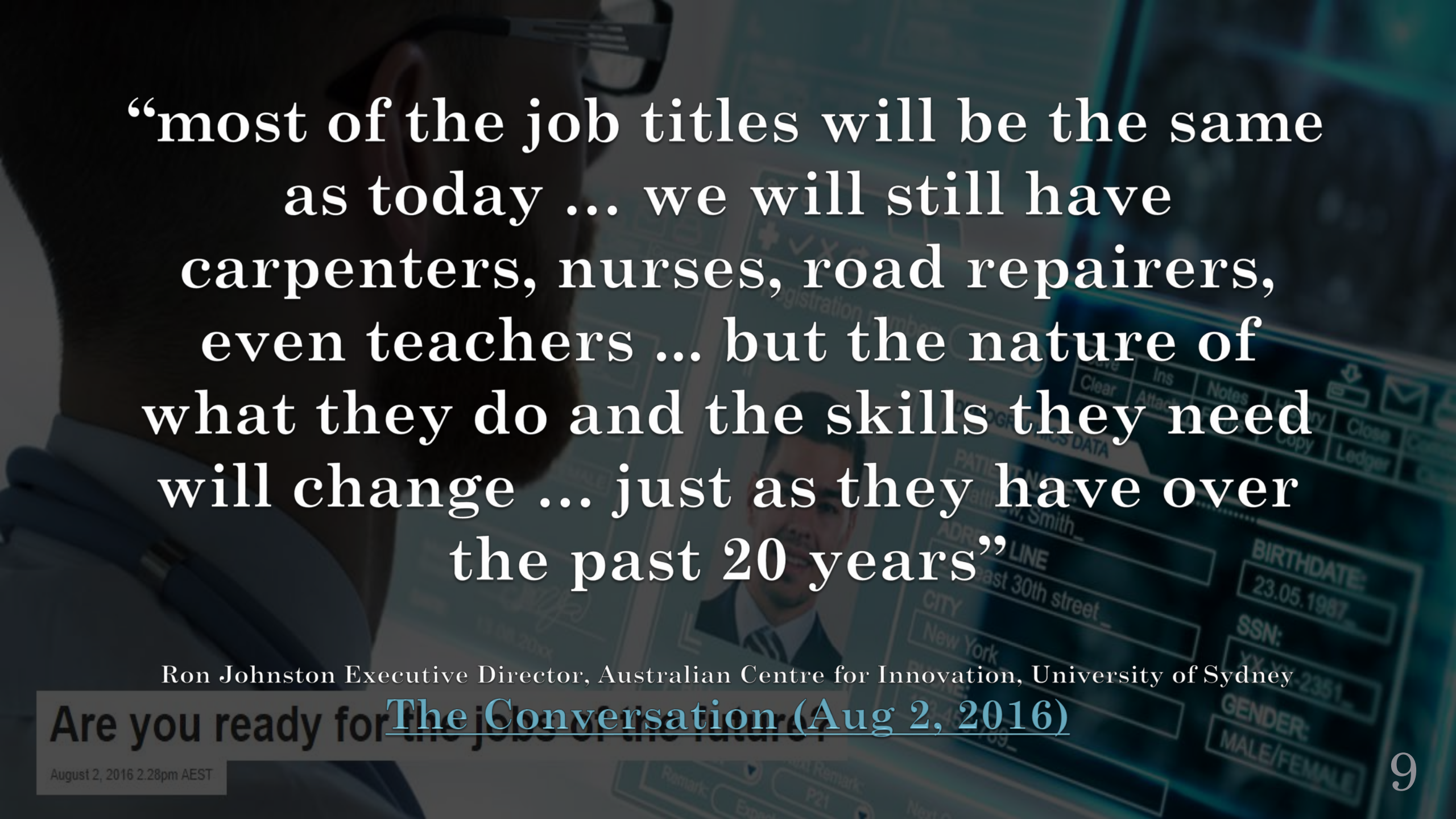
Nathan Taylor
CEDA Chief Economist

Ceda Workforce Policy 2015



Technology Drivers

Gartner



"most of the job titles will be the same as today ... we will still have carpenters, nurses, road repairers, even teachers ... but the nature of what they do and the skills they need will change ... just as they have over the past 20 years"

Ron Johnston Executive Director, Australian Centre for Innovation, University of Sydney

The Conversation (Aug 2, 2016)

Abilities

Cognitive Abilities
- Cognitive Flexibility
- Creativity
- Logical Reasoning
- Problem Sensitivity
- Mathematical Reasoning
- Visualization

Physical Abilities
- Physical Strength
- Manual Dexterity and Precision

Basic Skills

Content Skills
- Active Learning
- Oral Expression
- Reading Comprehension
- Written Expression
- ICT Literacy

Process Skills
- Active Listening
- Critical Thinking
- Monitoring Self and Others

Cross-functional Skills

Social Skills
- Coordinating with Others
- Emotional Intelligence
- Negotiation
- Persuasion
- Service Orientation
- Training and Teaching Others

Systems Skills
- Judgement and Decision-making
- Systems Analysis

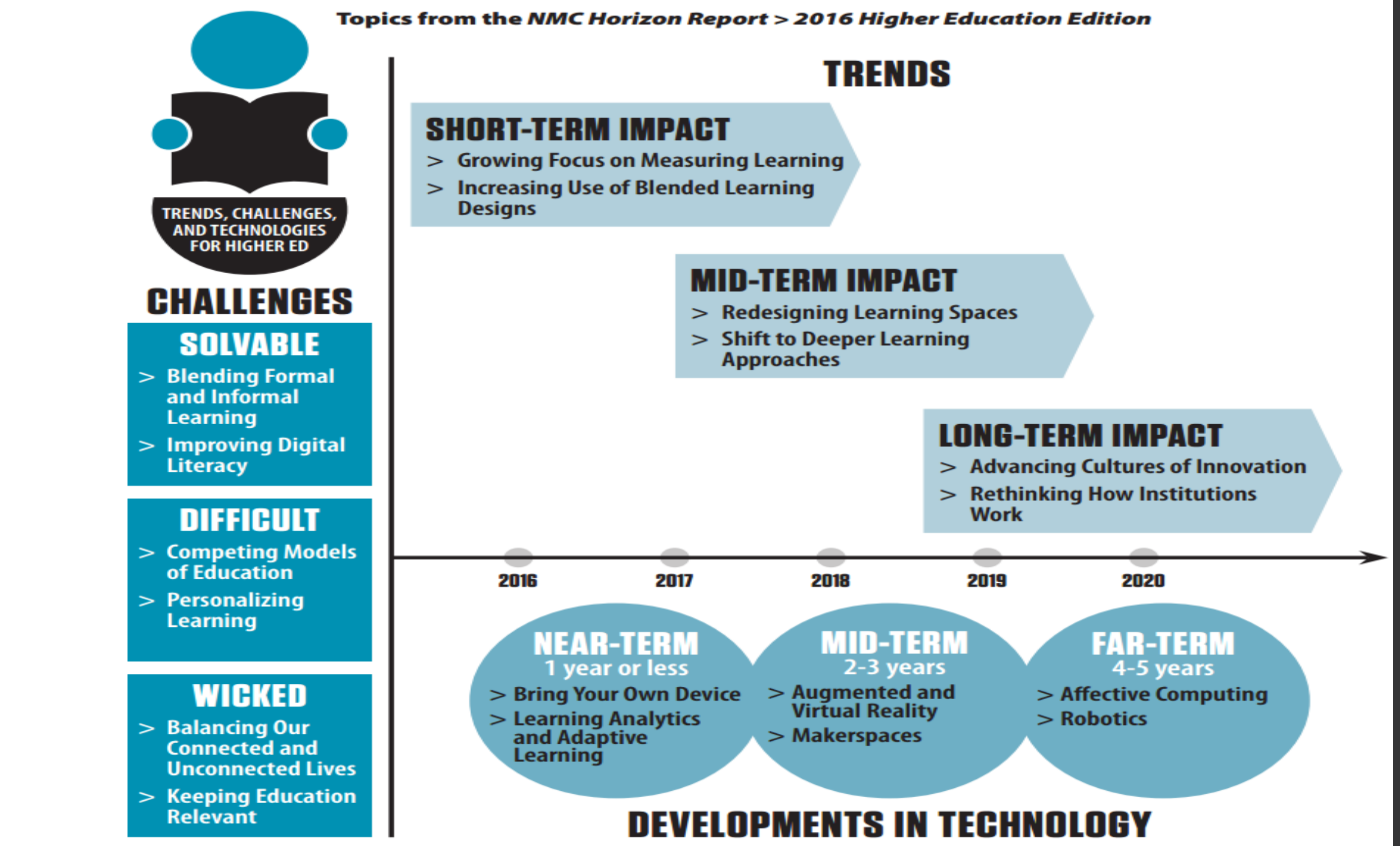
Complex Problem Solving Skills
- Complex Problem Solving

Resource Management Skills
- Management of Financial Resources
- Management of Material Resources
- People Management
- Time Management

Technical Skills
- Equipment Maintenance and Repair
- Equipment Operation and Control
- Programming
- Quality Control
- Technology and User Experience Design
- Troubleshooting

WORLD ECONOMIC FORUM

2016 – The Future of Jobs Report - Core work skills

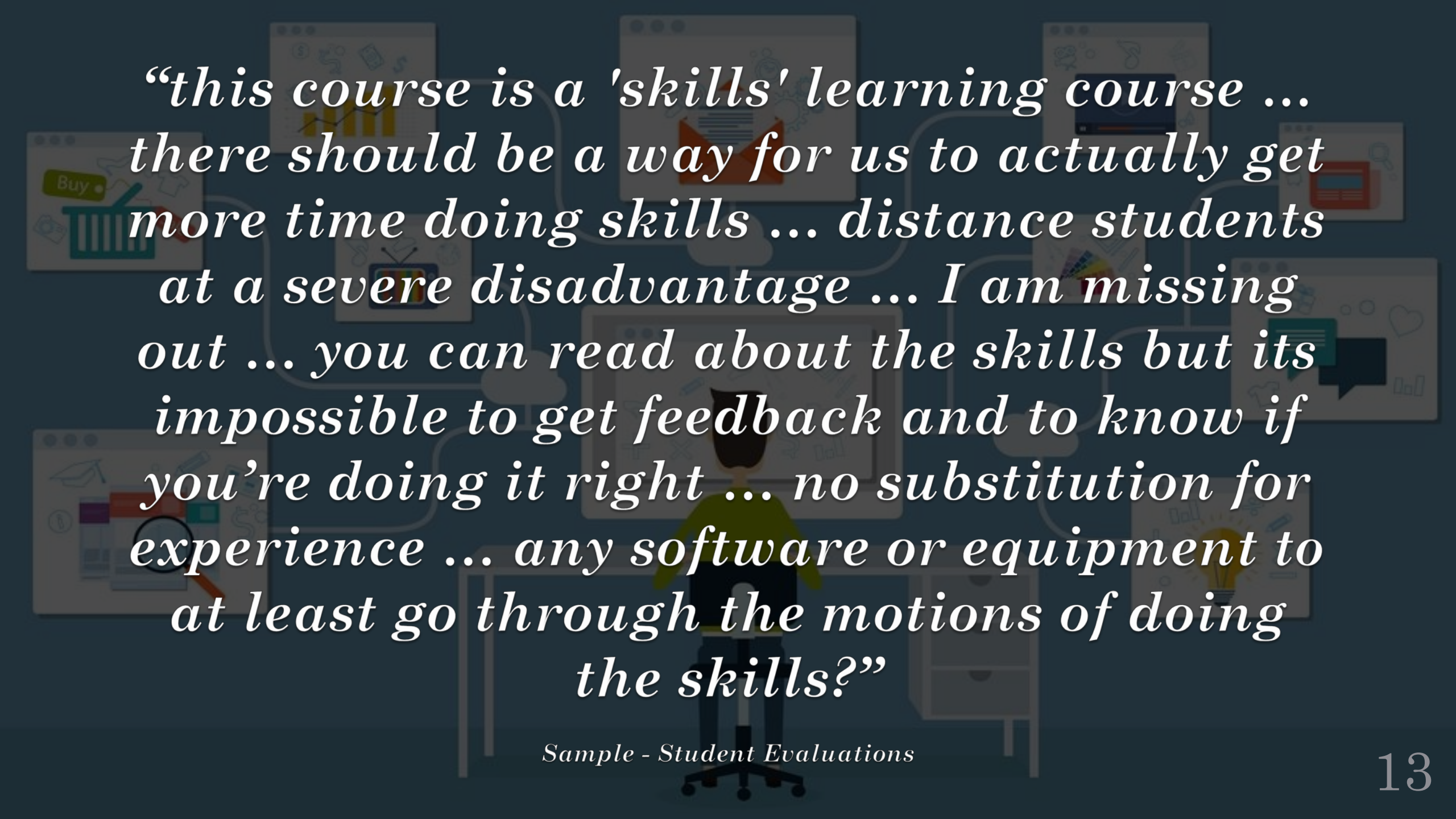

Topics from the NMC Horizon Report > 2016 Higher Education Edition
TRENDS, CHALLENGES, AND TECHNOLOGIES FOR HIGHER ED
CHALLENGES
SOLVABLE
> Blending Formal and Informal Learning
> Improving Digital Literacy
DIFFICULT
> Competing Models of Education
> Personalizing Learning
WICKED
> Balancing Our Connected and Unconnected Lives
> Keeping Education Relevant
TRENDS
SHORT-TERM IMPACT
> Growing Focus on Measuring Learning
> Increasing Use of Blended Learning Designs
MID-TERM IMPACT
> Redesigning Learning Spaces
> Shift to Deeper Learning Approaches
LONG-TERM IMPACT
> Advancing Cultures of Innovation
> Rethinking How Institutions Work
2016
2017
2018
2019
2020
NEAR-TERM
1 year or less
> Bring Your Own Device
> Learning Analytics and Adaptive Learning
MID-TERM
2-3 years
> Augmented and Virtual Reality
> Makerspaces
FAR-TERM
4-5 years
> Affective Computing
> Robotics
DEVELOPMENTS IN TECHNOLOGY

NMC Horizon Report 2016 Higher Education Edition	2016 Technology Outlook for Australian Tertiary Education	2015 Technology Outlook for Australian Tertiary Education
Time-to-Adoption Horizon: One Year or Less		
Bring Your Own Device Flipped Classroom Learning Analytics/Adaptive Online Learning	Bring Your Own Device Flipped Classroom Learning Analytics Online Learning	Bring Your Own Device Cloud Computing Flipped Classroom Learning Analytics
Time-to-Adoption Horizon: Two to Three Years		
3D Printing Augmented/Virtual Reality Makerspaces Wearable Technology	Adaptive Learning Technologies Location Intelligence Makerspaces Wearable Technology	Badges/Microcredit Mobile Learning Open Licensing Wearable Technology
Time-to-Adoption Horizon: Four to Five Years		
Affective Computing Next-Generation Batteries Quantified Self Robotics	Affective Computing Augmented Reality Machine Learning Networked Objects	Adaptive Learning Technologies Augmented Reality Quantified Self Telepresence

2016 NMC Technology Outlook

Australian Tertiary Education

A Horizon Project Regional Report



“this course is a 'skills' learning course … there should be a way for us to actually get more time doing skills … distance students at a severe disadvantage … I am missing out … you can read about the skills but its impossible to get feedback and to know if you’re doing it right … no substitution for experience … any software or equipment to at least go through the motions of doing the skills?”

Sample - Student Evaluations

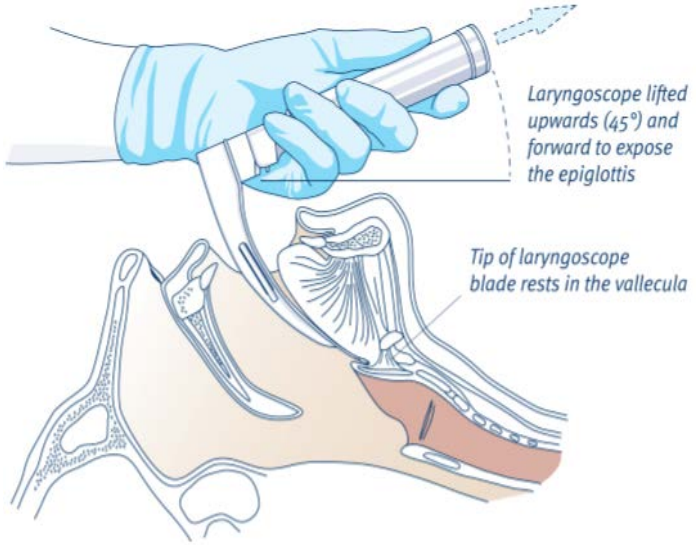
How Mixed Reality Pedagogy fits in

Background Research

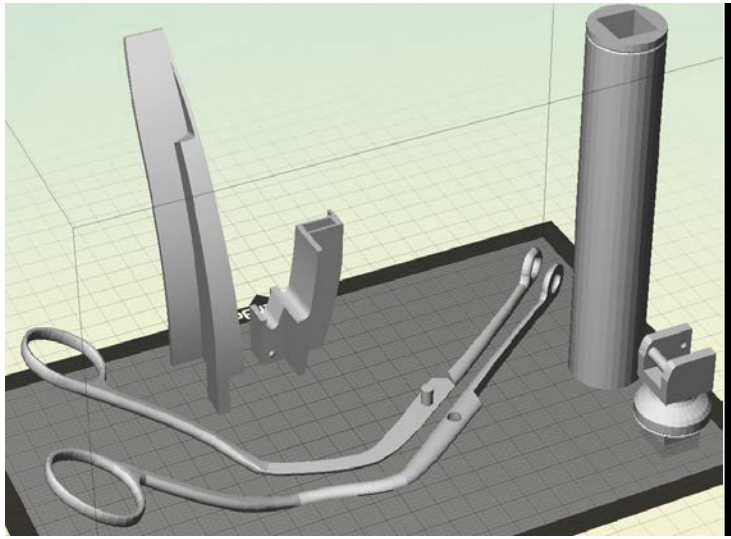
- Difficult to teach complex processes - without real world models (Tasker & Dalton, 2008)
- Traditional teaching methods often use abstract visualizations – but don't capture complexity (Williamson et al., 2012)
- Focus on technology enhanced T&L (Johnson et al., 2016; Keppell et al., 2011)
- Visualizations are positive learning support tools (Mayer, 2014; Höffler, 2010)
- Kinaesthetic tools better form mental models (Pass & Sweller, 2014)

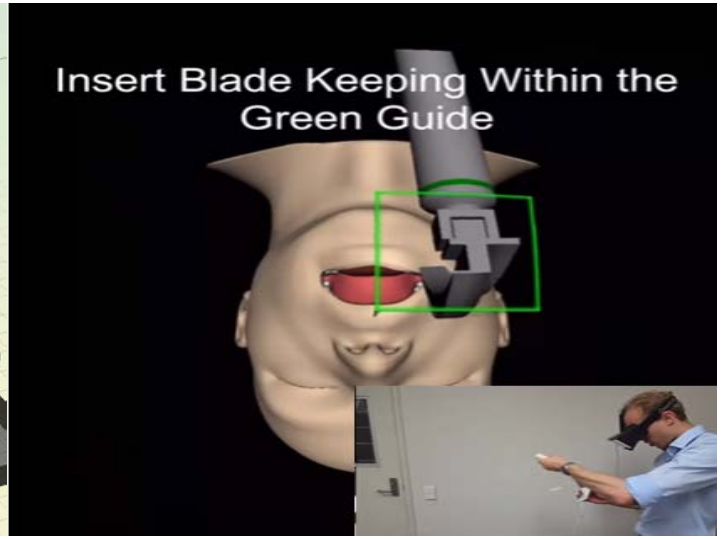
Most prior work in (multimedia…blended…dual modality) learning has been formed around words & pictures with less attention to complex learning environments such as interactive visualisations, games & simulations (Ayres, 2015)

Case Study: Mixed Reality Simulation in Paramedic Distance Education

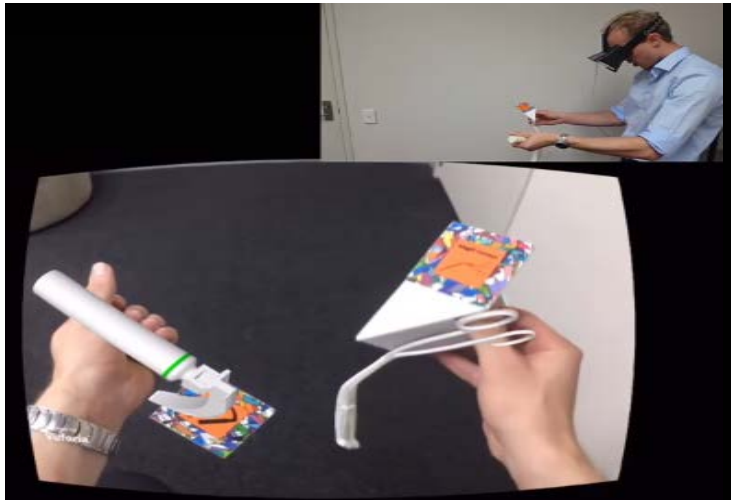


Traditional Teaching Method

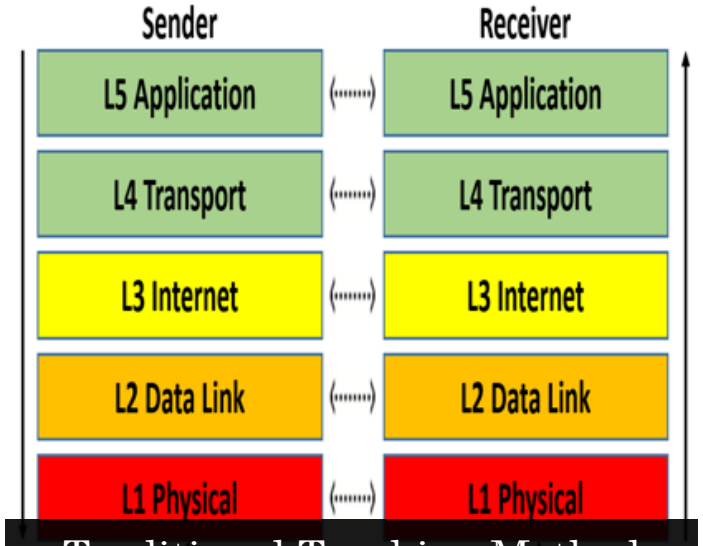




Mixed Reality Pedagogy

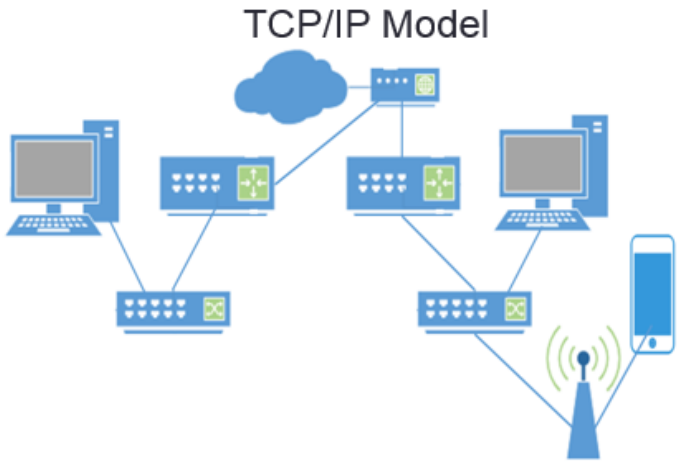


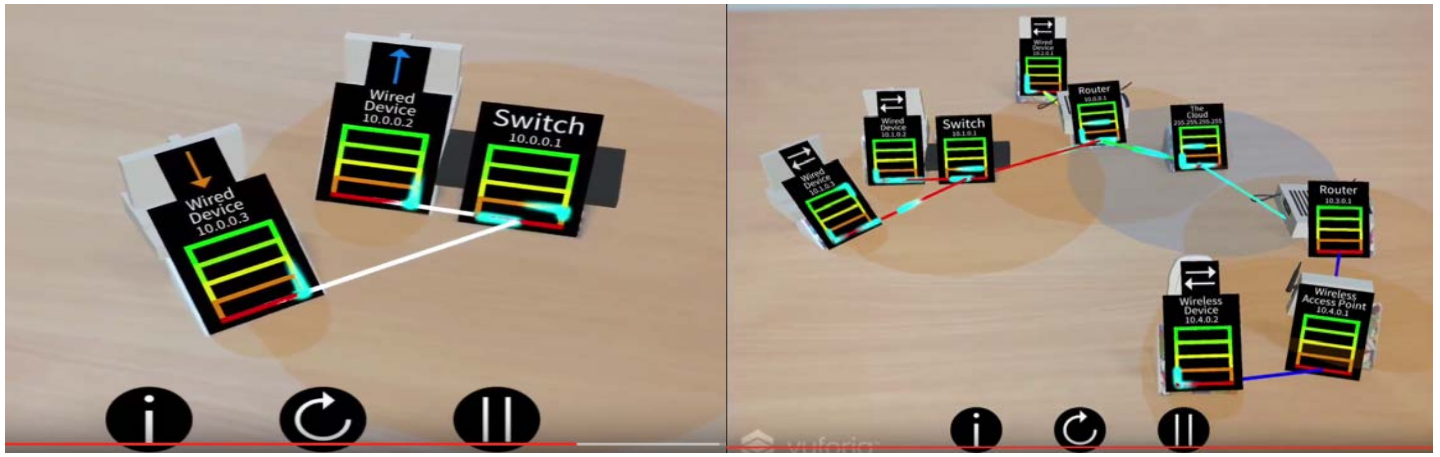
Case Study: Mixed Reality in ICT Networking to Visualize Complex Theoretical Multi-Step Problems



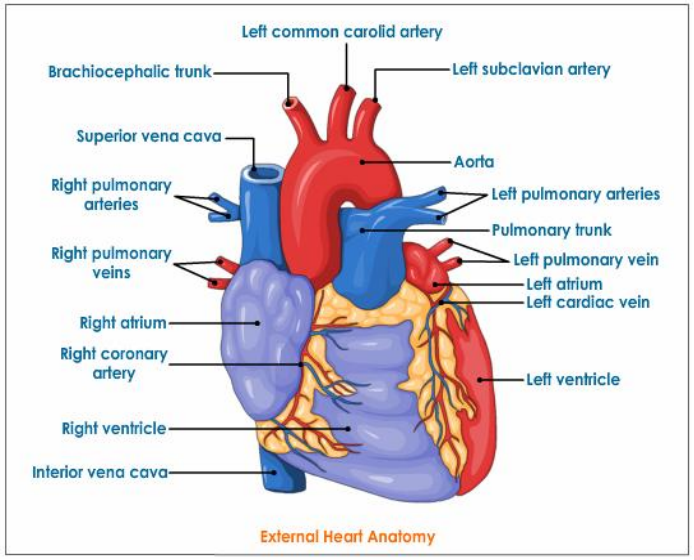
Traditional Teaching Method

Mixed Reality Pedagogy

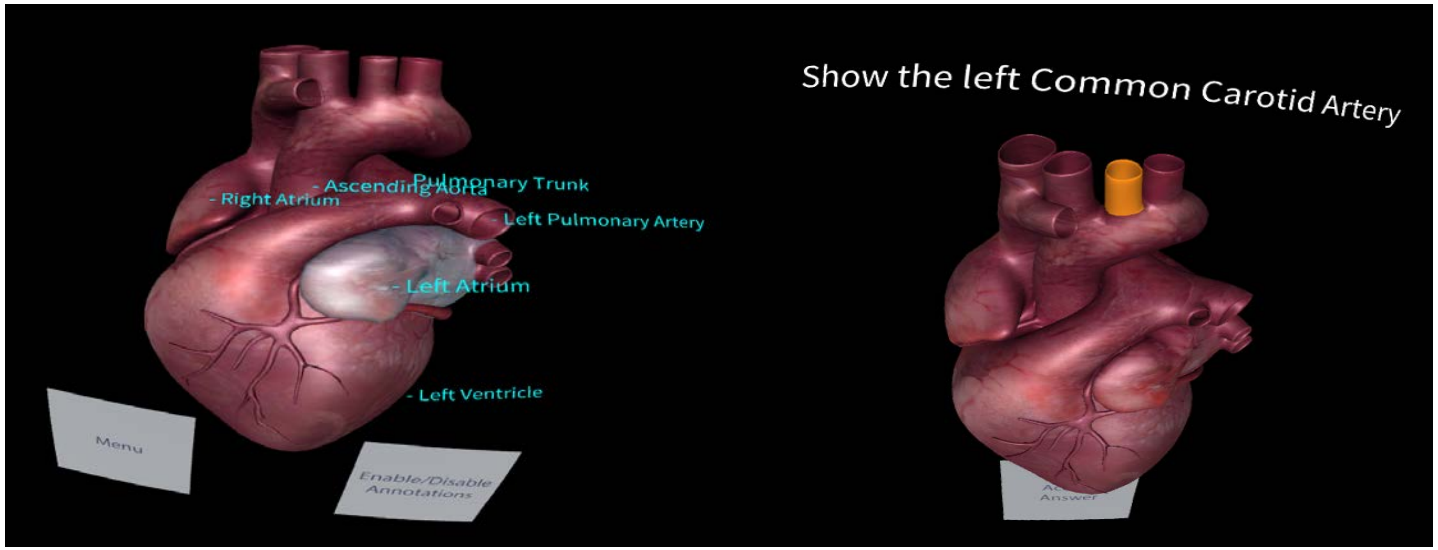




Case Study: Mixed Reality and Spatial Learning Analytics to Facilitate Learning of Anatomy



Traditional Teaching Method



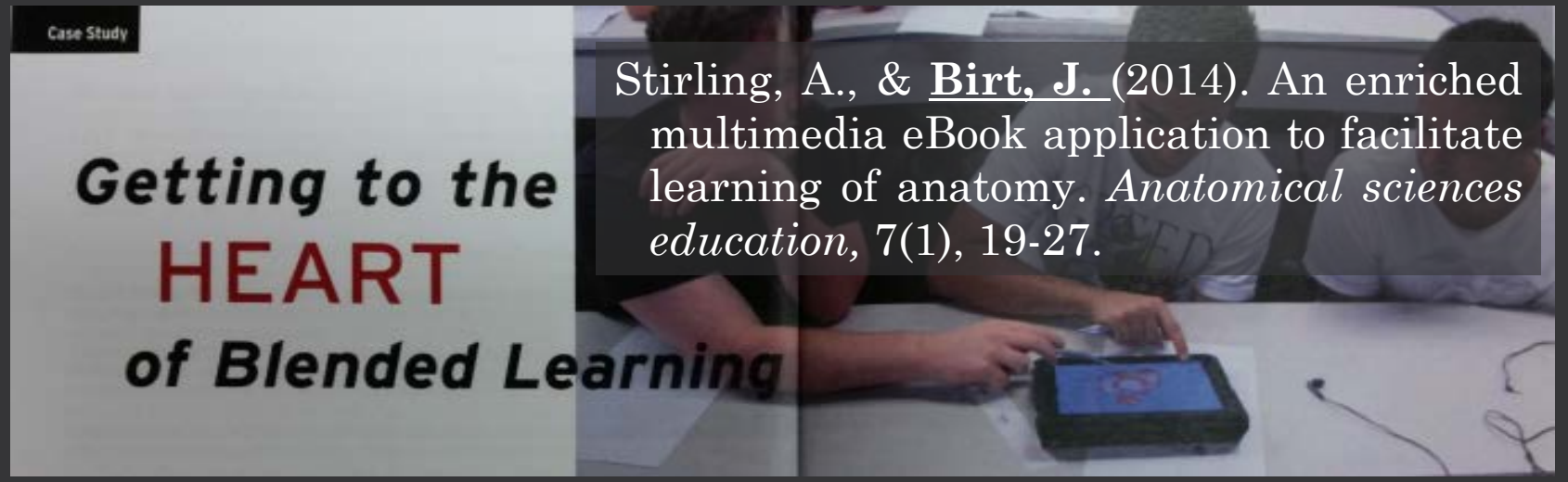
Mixed Reality Pedagogy

Hands-On
→ Take some time to explore the three (3) case studies

- Paramedics app available on google play and IOS app store – search 'Laryngoscopy AR' – requires a head mounted google cardboard device
- Networking app available on google play and IOS app store – search 'Networking AR' – can be used on any phone or tablet device
- Heart MR → currently available via phones in the room or built to your android device (only)
- Tools & markers are available in the room

If you download an app and want to use it later, all markers and 3d printable files are available at www.mixedrealityresearch.com

Mixed Reality in Higher Education: Pedagogy Before Technology - Visualisation Feedback Survey						
Visualisation:	Paramedics ||	Networking ||				Anatomy
QUESTIONS (Please cross the most appropriate response) - Likert Scale 1 - 5 - use 0 for N/A						
Accessibility: being accessible or available for use	0	1	2	3	4	5
Learnability: allowing accomplishment of the learning objective	0	1	2	3	4	5
Cost: affordability in terms of monetary cost or efficiency in terms of time	0	1	2	3	4	5
Satisfaction: providing confidence in meeting the learning objective	0	1	2	3	4	5
Memorability: effectiveness or ease of re-establishing proficiency of the learning objective after a period (length) of time (past activities)	0	1	2	3	4	5
Usability: responsiveness, robustness, stability or errors in use (e.g. motion sickness, frame rates, bugs)	0	1	2	3	4	5
Manipulability: allowing interactive variable manipulation e.g. rotation, time, scene objects, etc.	0	1	2	3	4	5
Navigability: allowing spatial translation of the viewpoint	0	1	2	3	4	5
Visibility: providing a clear interface design to observe (vision) and interpret the learning objective	0	1	2	3	4	5
Fidelity: providing an accurate representation of the real world (including visual, touch and sound)	0	1	2	3	4	5
Communication: supporting discussion of learning objectives between stakeholders (instructor, learners, others)	0	1	2	3	4	5
Creativity: allowing emergent, creative, playful discovery towards the learning objectives	0	1	2	3	4	5
Engagement: novelty, aesthetics, or feedback to focus learner attention and involvement on the learning objective	0	1	2	3	4	5
Motivation: wanting to complete the learning objective	0	1	2	3	4	5
Additional Comments						

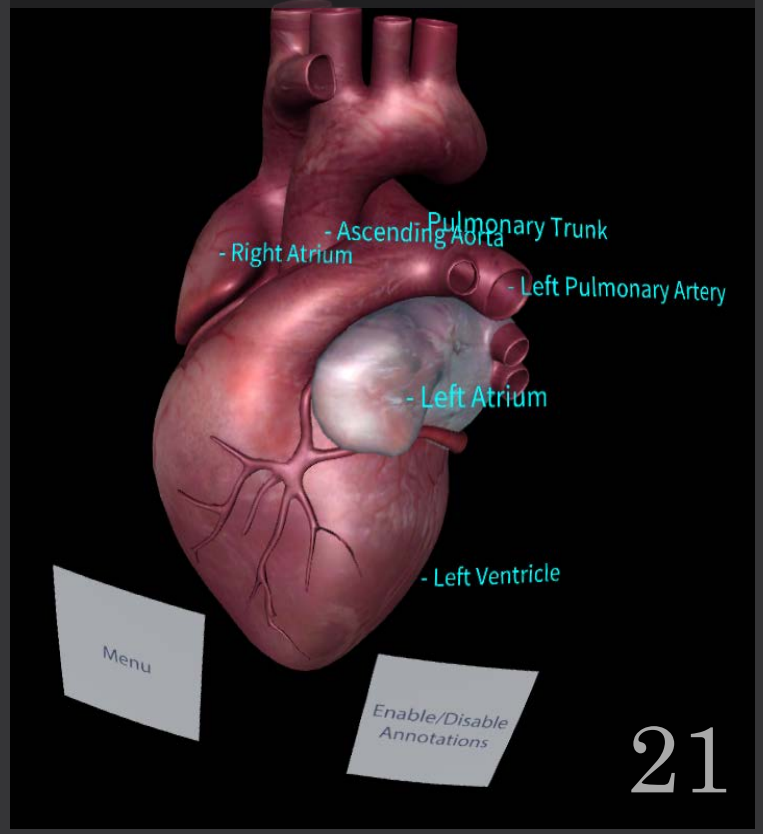


Stirling, A., & **Birt, J.** (2014). An enriched multimedia eBook application to facilitate learning of anatomy. *Anatomical sciences education*, 7(1), 19-27.

Follow up Study – Using Mixed Reality + Analytics

Heart MR →Breakdown

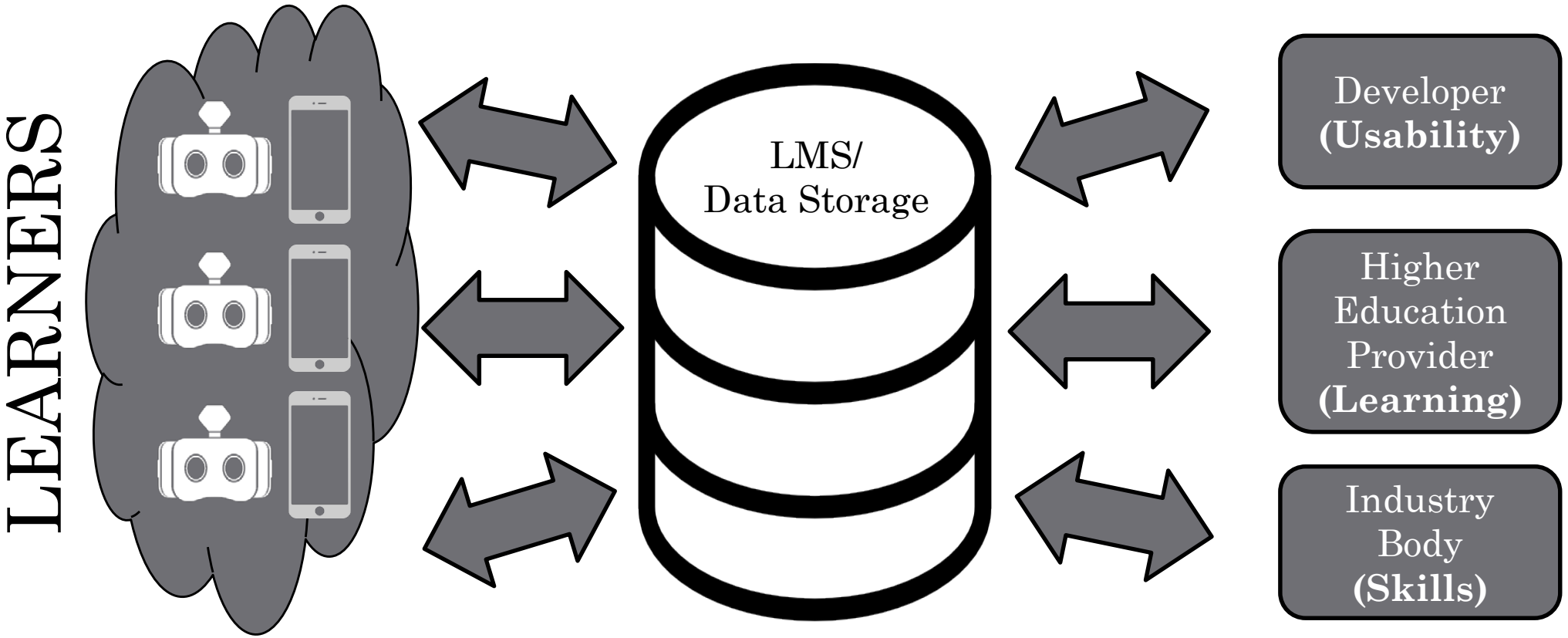
Capture learner <> mixed reality material interaction(s) and learning outcomes



Analytics: Capture learner <> mixed reality material interaction(s) and learning outcomes

	Past	Present	Future
Information	What happened? (Reporting)	What is happening now? (Alert)	What will happen? (Extrapolation)
Insight	How and did it happen? (modelling, experimental design)	What's the next best action? (Recommendation)	What's the best/worst that can happen? (prediction, optimisation, simulation)
Davenport et al., (2010)			

Model



[BYOD Mixed Reality Simulation Pedagogy]
Learning Outcomes + Spatial Interaction Data

[Evidence]
Analytics + Visualisation(s)

Simulation Construction Tools

- Unity3d game engine (www.unity3d.com)
- Vuforia augmented reality plugin (www.vuforia.com/)
- MySQL (www.mysql.com/)
- Php (secure.php.net/)
- Google Cardboard headset (vr.google.com/cardboard/)

Introductory AR in Unity3d using Vuforia

→ Beginners Guide Only using a single image target

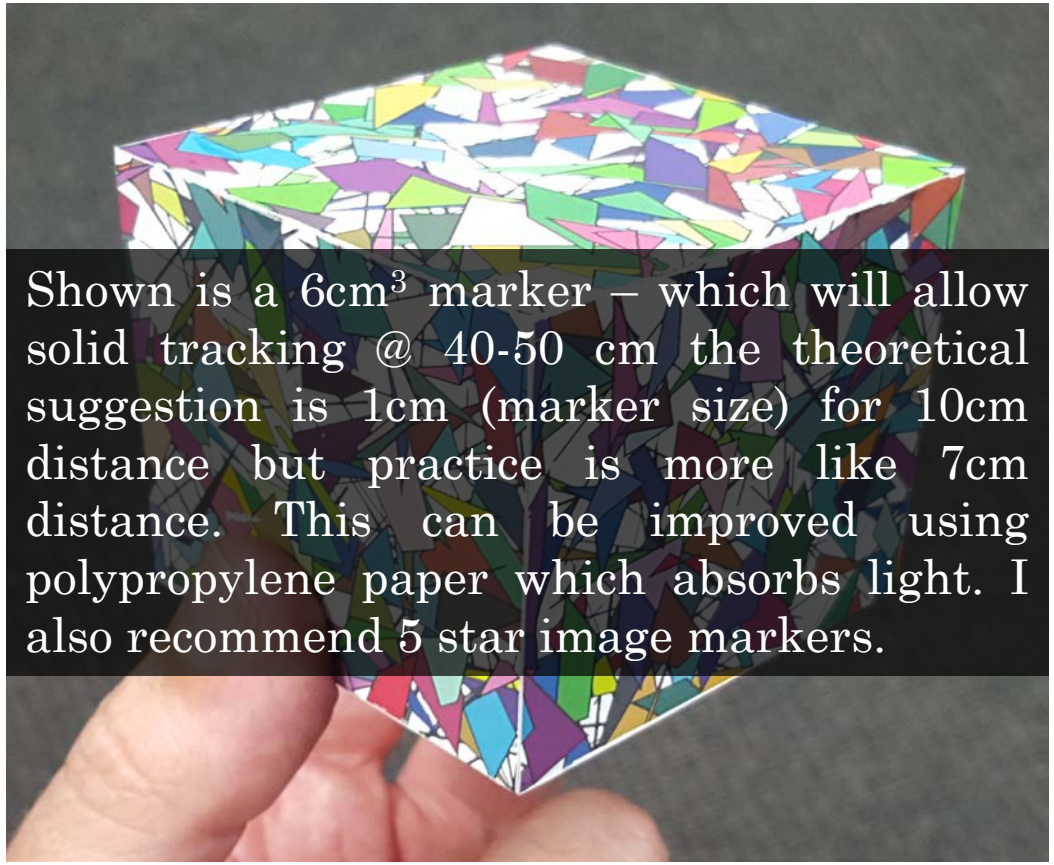
Dr James Birt

tinyurl.com/IntroUnityAR

Vuforia with Multitargets for AR/VR → Allows 360^0 physical rotation

- developer.vuforia.com
- Signup
- Downloads > Samples > Digital Eyewear > Unity3d: AR/VR Sample scene
- Develop > License Manager > Add License Key
- Develop > Target Manager > Add Database
- Develop > Target Manager > [DBName] > Add Target(s) – this example uses six (6)
- Develop > Target Manager > [DBName] > Download Database

library.vuforia.com/guide

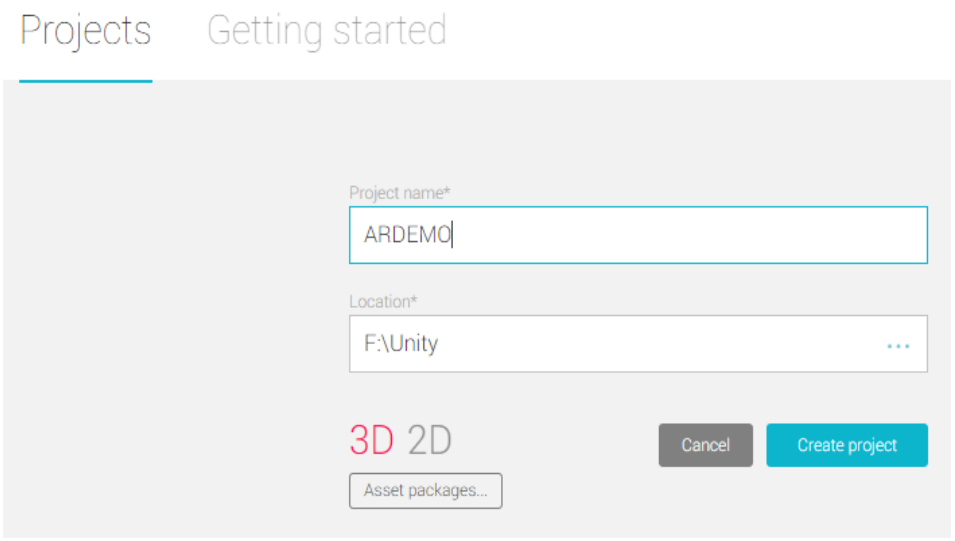


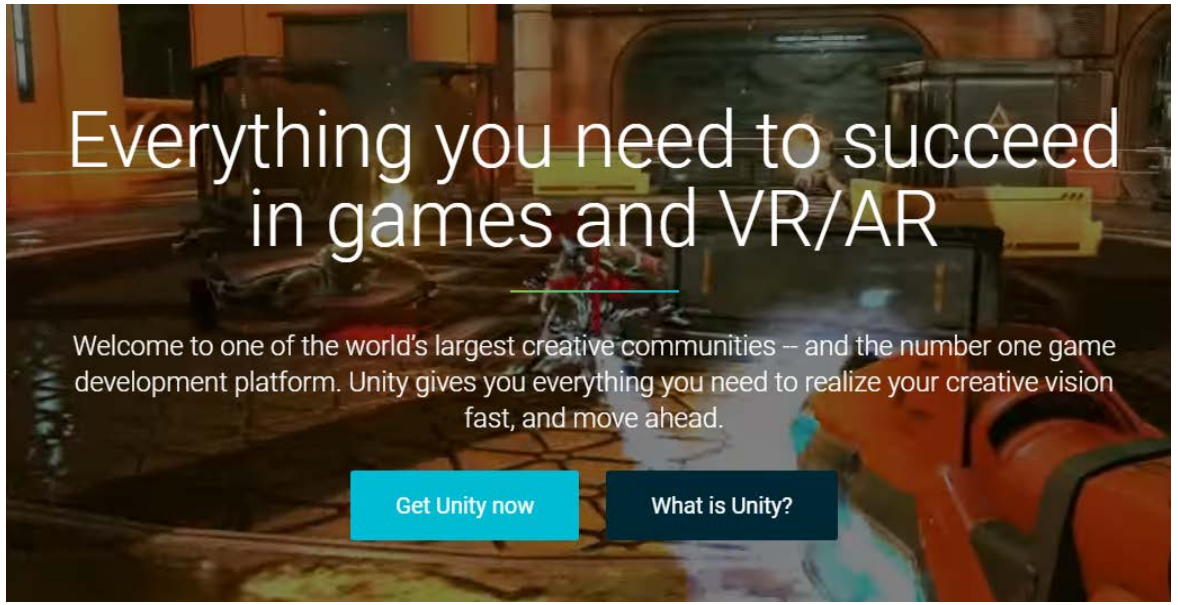
Shown is a $6cm^3$ marker – which will allow solid tracking @ 40-50 cm the theoretical suggestion is 1cm (marker size) for 10cm distance but practice is more like 7cm distance. This can be improved using polypropylene paper which absorbs light. I also recommend 5 star image markers.

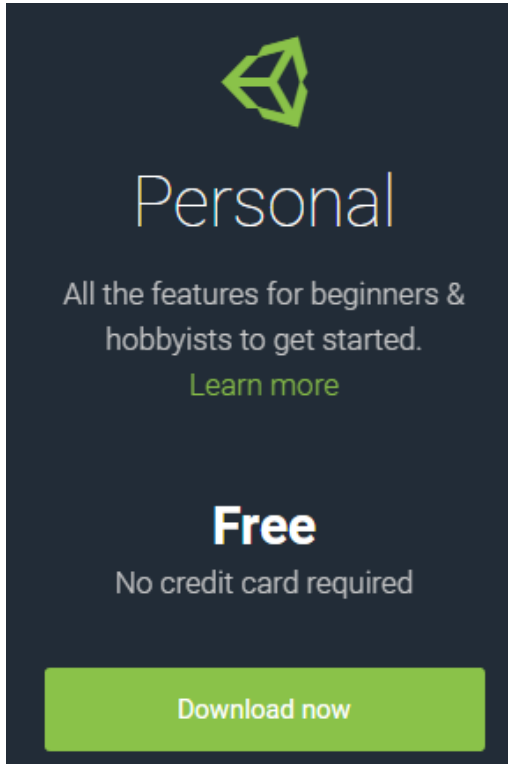
brosvision.com/ar-marker-generator/

Unity3d

- Download Unity3d
- Create new Project
- Import Digital Eyewear Scene
- Import Image Database



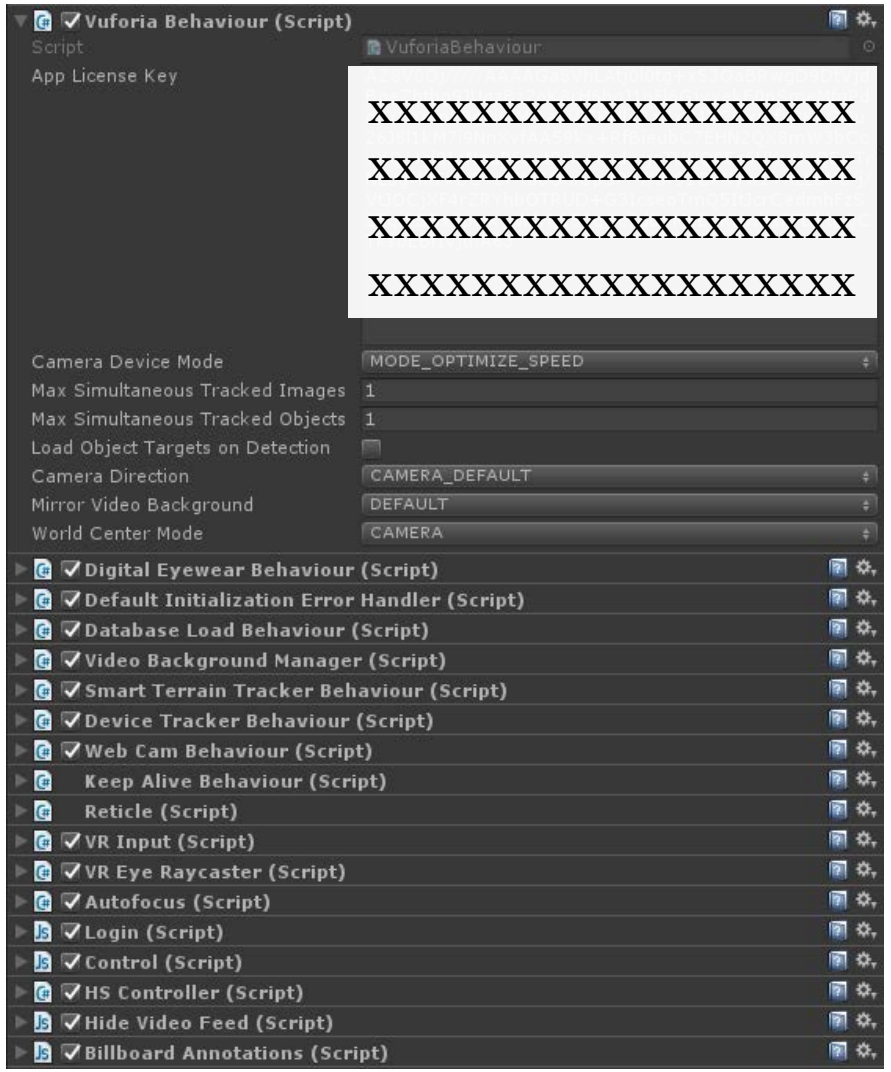




unity3d.com/

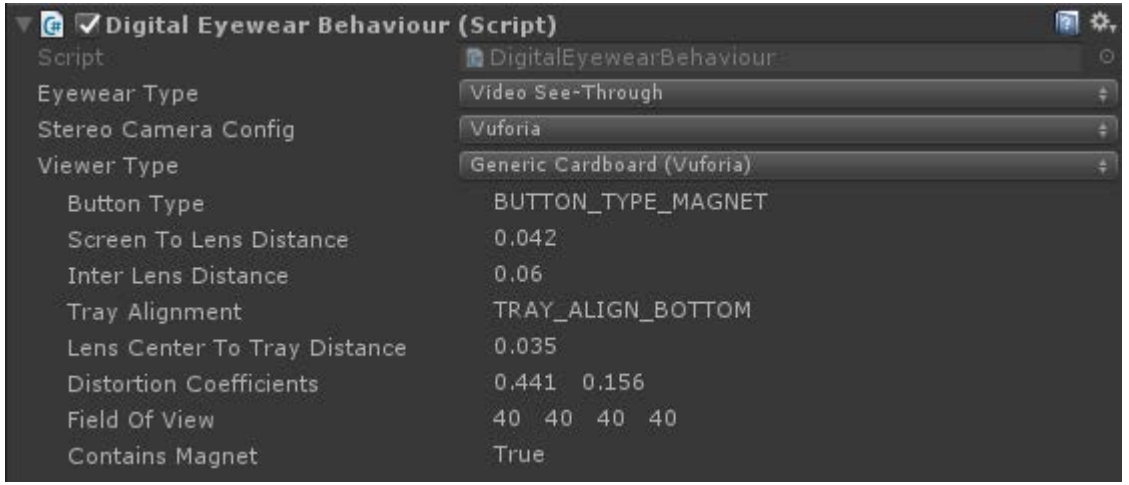
AR Camera (Vuforia Behaviour)

- Click the ARCamera and view the inspector window
- Vuforia Behaviour (Script) – copy your license key to the Vuforia Behaviour Script App License Key
- Switch the Camera Device Mode to MODE_OPTIMIZE_SPEED – this will help with real-time image movement & pickup
- For now I will leave Tracked Images & Objects at one (1) but if you want to track multiple targets you will need to modify this number
- *Please note: Even though we are using a Multi target marker we are only ever tracking one (1) target at a time*

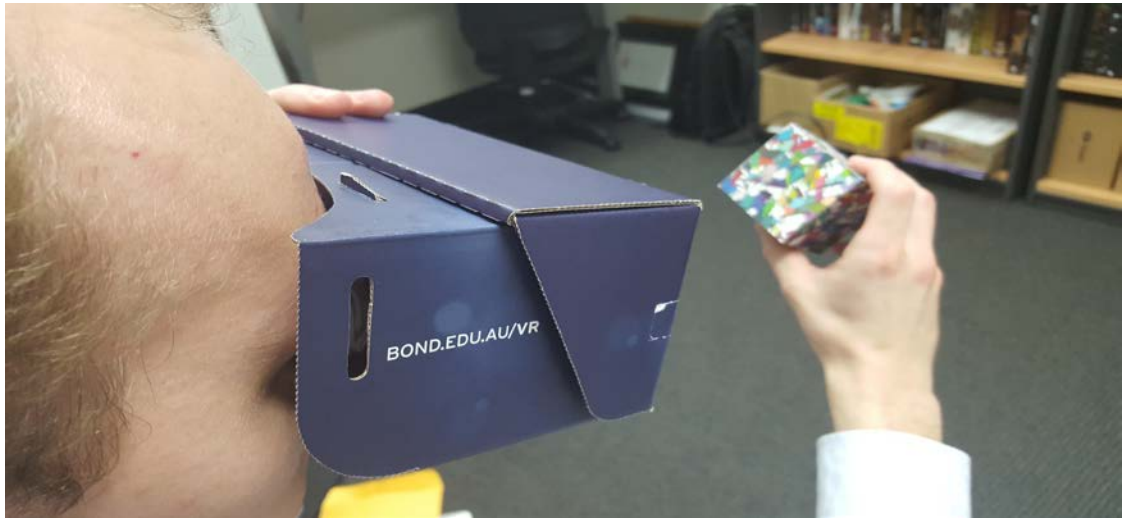


AR Camera (Digital Eyewear)

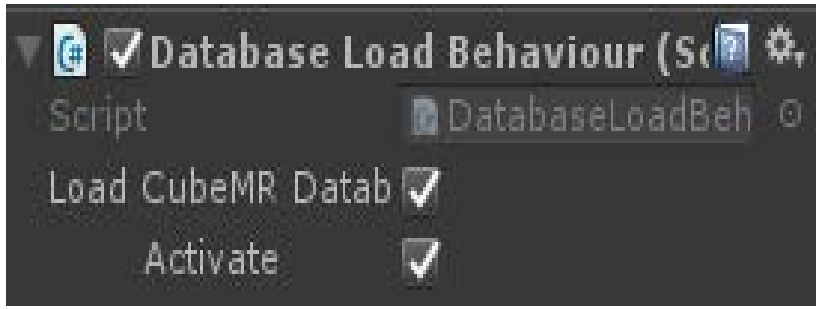
- For this example we are using a generic Google Cardboard
- This method uses a video see-through method using your BYOD mobile phone

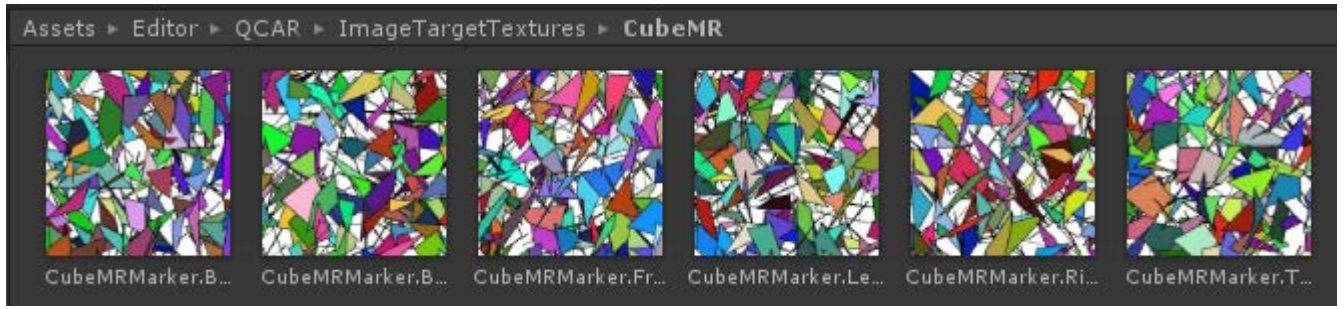


library.vuforia.com/articles/Training/Vuforia-for-Digital-Eyewear



AR Camera (Database Load)






```
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        <ImageTarget name="CubeMRMarker.Top" size="6.000000 6.000000"/>
        <ImageTarget name="CubeMRMarker.Front" size="6.000000 6.000000"/>
        <ImageTarget name="CubeMRMarker.Back" size="6.000000 6.000000"/>
        <ImageTarget name="CubeMRMarker.Bottom" size="6.000000 6.000000"/>
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            <Part name="CubeMRMarker.Right" translation="3.0 0 0" rotation="AD: 0 1 0 90"/>
            <Part name="CubeMRMarker.Front" translation="0 0 3.0" rotation="AD: 1 0 0 0"/>
            <Part name="CubeMRMarker.Back" translation="0 0 -3.0" rotation="AD: 0 1 0 180"/>
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            <Part name="CubeMRMarker.Bottom" translation="0 -3.0 0" rotation="AD: 1 0 0 90"/>
        </MultiTarget>
    </Tracking>
</QCARConfig>
```
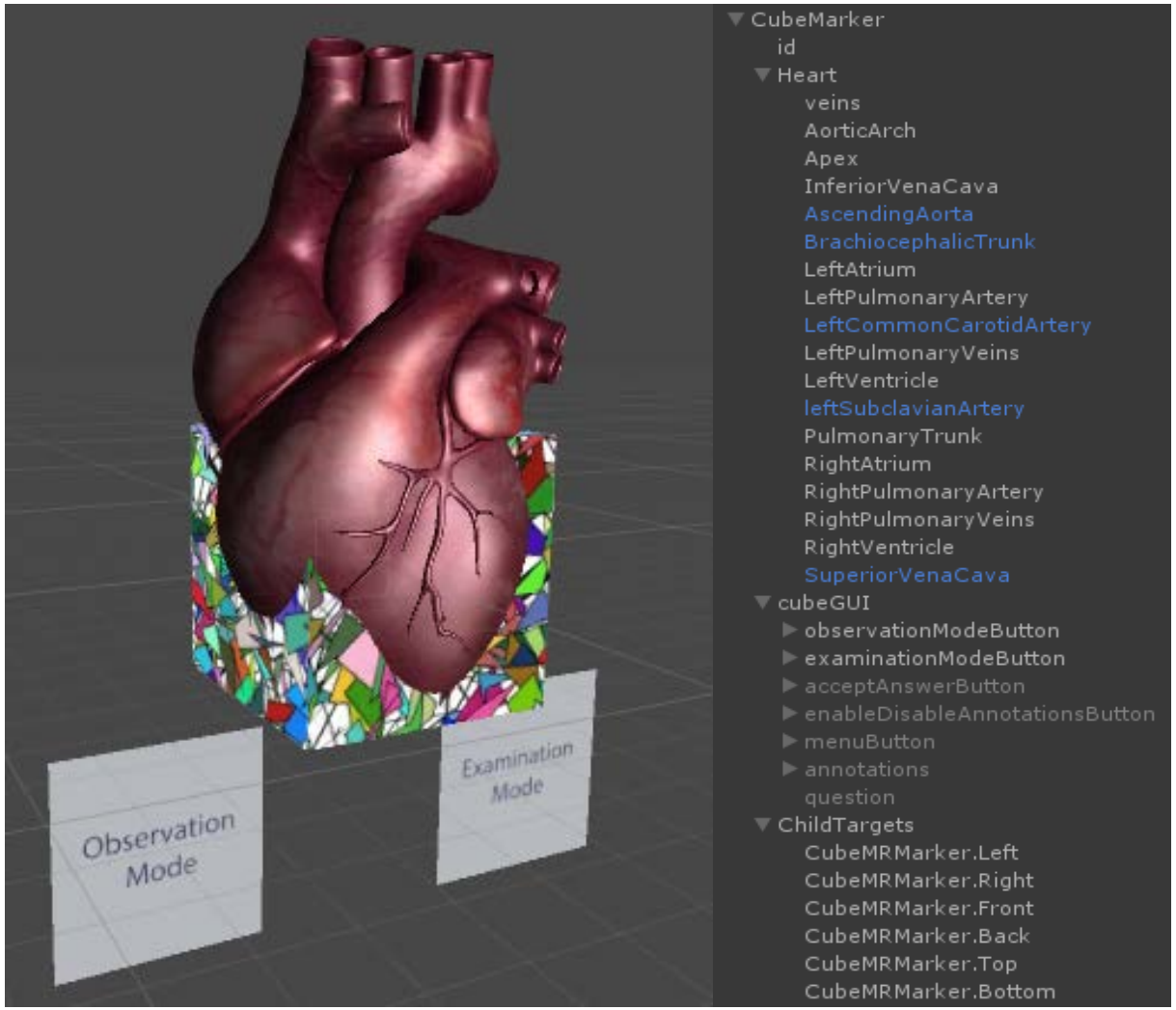
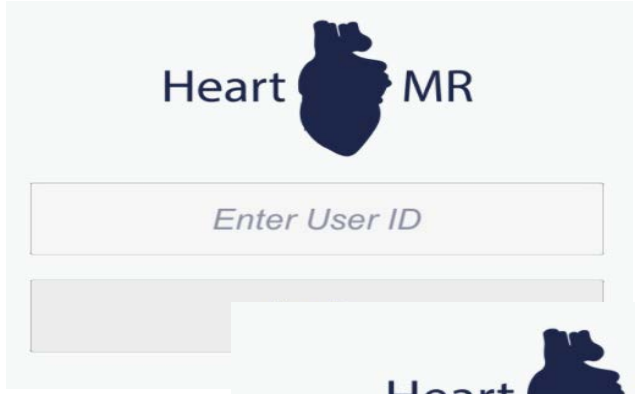
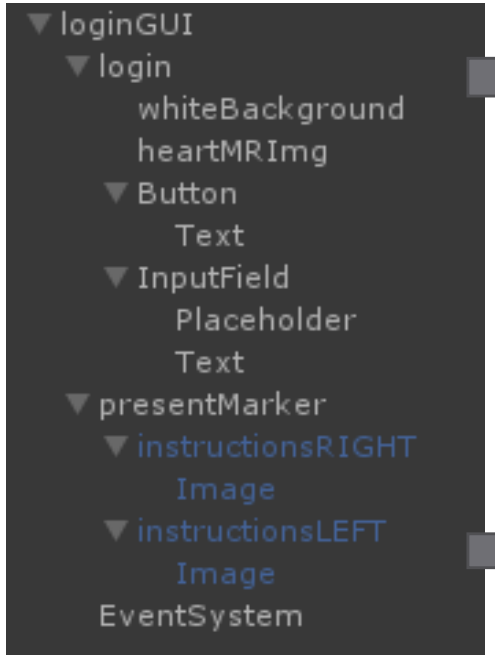

Add AR/VR asset(s) to scene

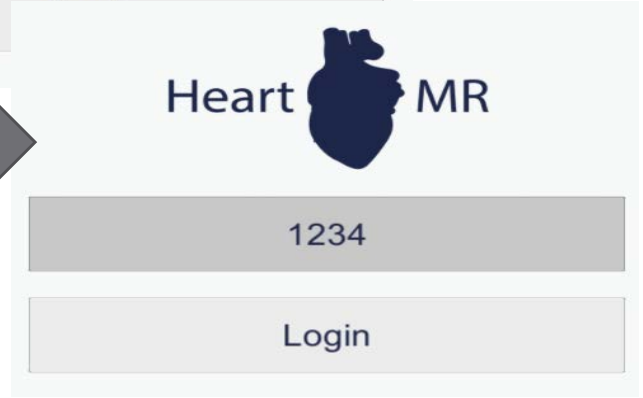
- Drag an instance of the MultiTarget prefab into your scene – rename e.g. CubeMarker
- Set your ChildTargets to each of your Image Markers from your database – turn off mesh renderer – you don't want to see the cube
- Place your 3d model onto your marker and make it a child
- Add any 3d spatial GUI elements to your marker



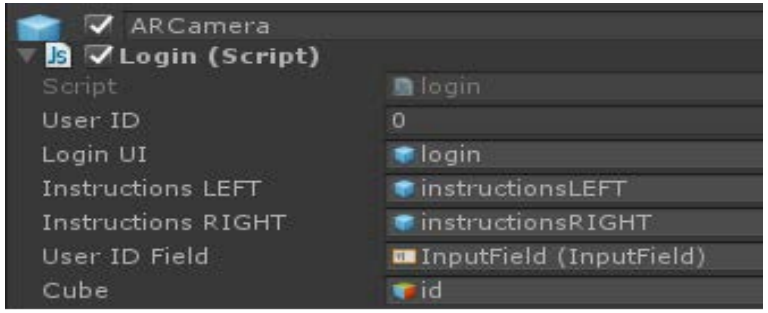
Simulation Breakdown → Login



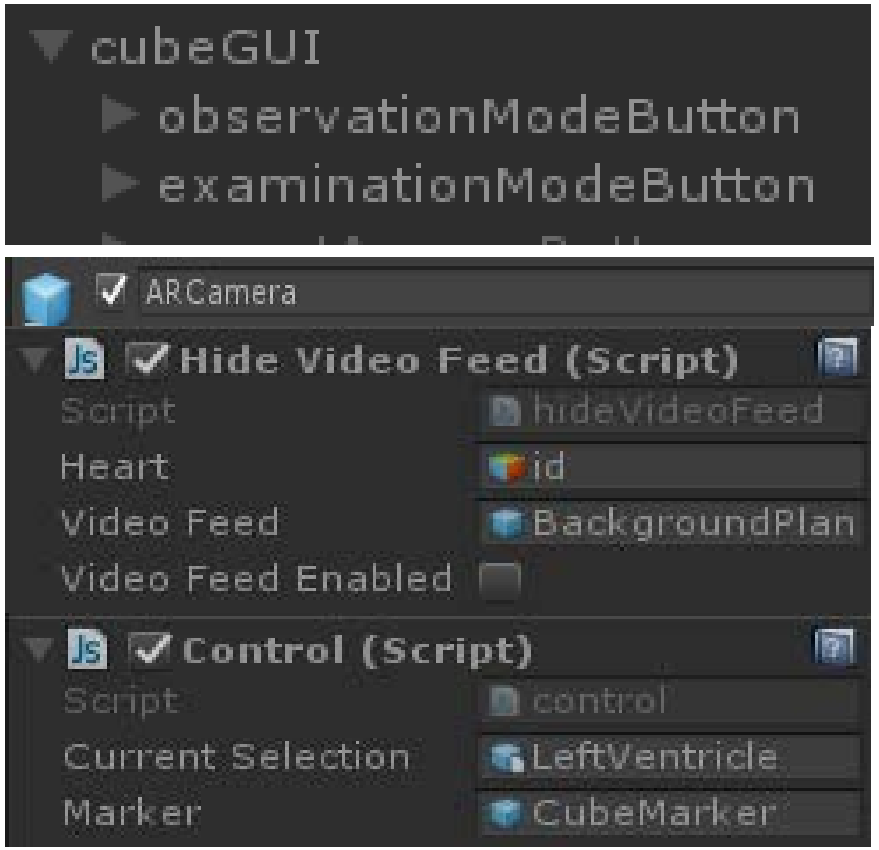




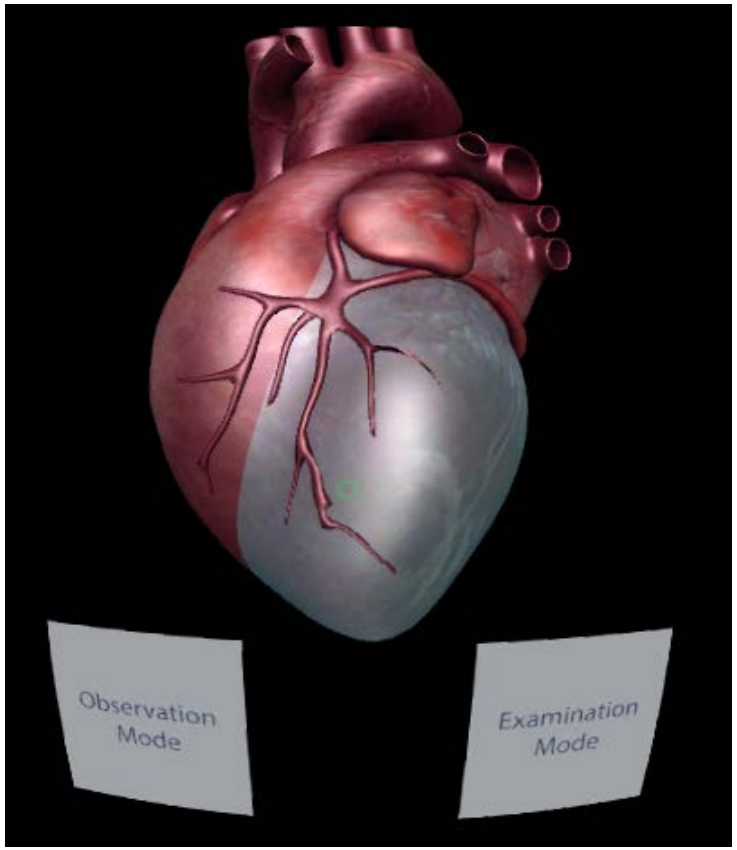
- Display login GUI
- Allow login entry – in this demo we allow all logins (for authentication you would query your user database)
- Record details
- On successful Login - Display marker instructions



Simulation Breakdown → Main Menu

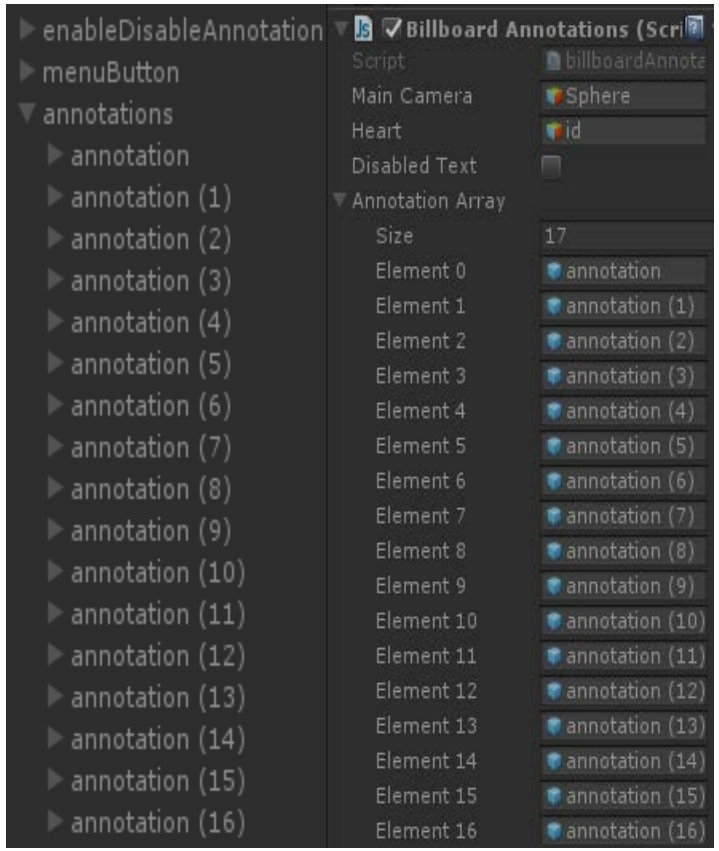


When marker found - switch off camera feed to focus user attention … user(s) virtual arm has been established with the AR setup. The marker is still tracked in real-time but distraction is reduced.

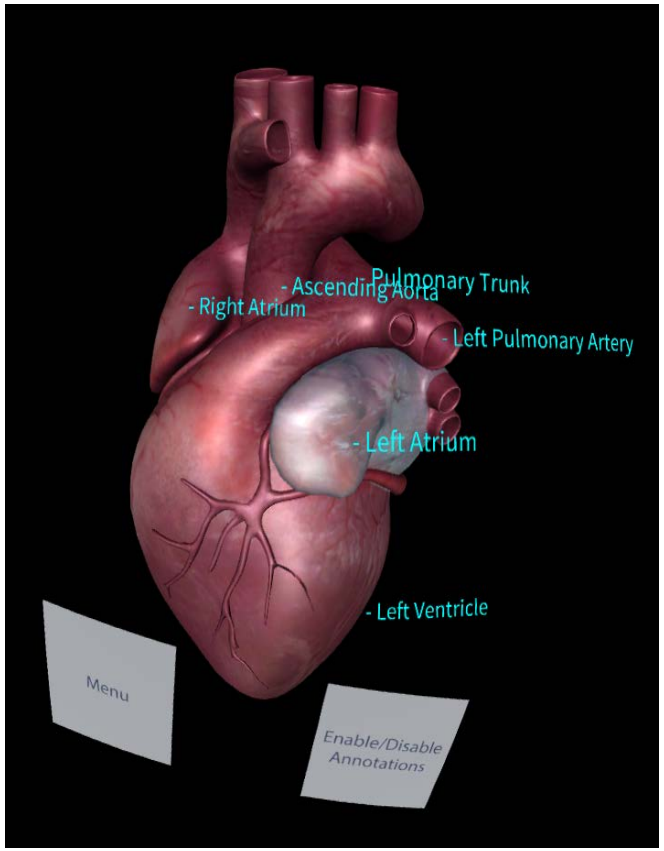


- Turn off Login & Marker display GUI
- Turn on Spatial GUI Menus – Learner Observation Mode & Examination Mode

Simulation Breakdown → Learner Observation Mode

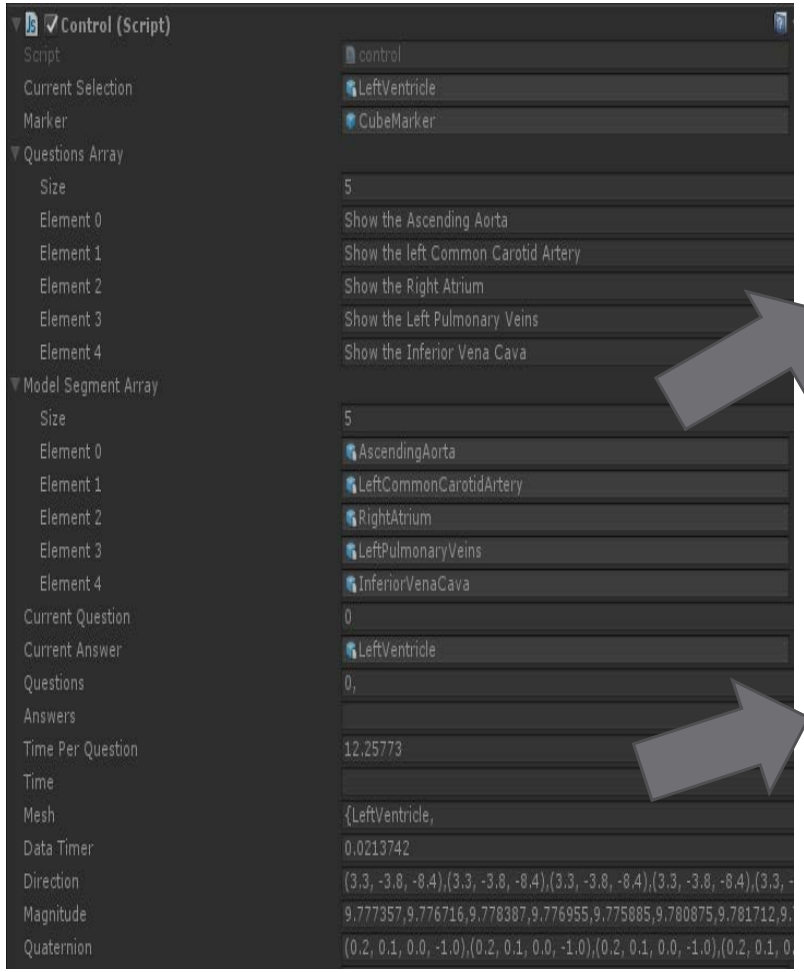


As the user physically moves the cube (or their head) annotations become visible. The user can also highlight elements of the model by focusing the reticule over the mesh object. This establishes a spatial connection to the user. The user can turn on or off annotations by focusing the reticule over the menu items.

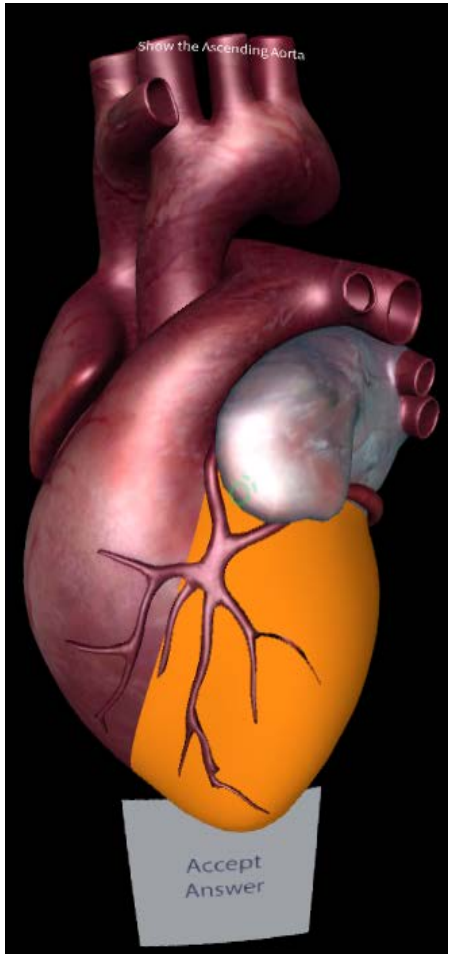


- Turn off Spatial GUI Menus – Learner Observation Mode & Examination Mode
- Turn on Annotation (on/off) Mode – This allows for user(s) formative learning

Simulation Breakdown → Learner Examination Mode



- Questions are randomised in this case five (5) sample questions
- As the user selects answers these are added to the mesh array for later storage – we record all focused meshes to record how the user interacts (e.g. confusion/uncertainty – flipping between meshes)
- A timer is recorded per question
- Spatial 3d data is recorded 24x/s to allow for observation replay
- Direction: {X,Y,Z} cube translation
- Magnitude: cube distance to camera
- Quaternion: {X,Y,Z,w} cube rotation



Simulation Breakdown → Data (Analytics) Storage

- Create unity WWWForm();
- Add fields using form.AddField();
- $Post - URL/phpfile using WWW(URL, form);
- phpfile: create timestamp: date('Y-m-d H:i:s'); & update database – for the example this is hardcoded – you should check authentication
- Wait for write confirmation & send back to Unity
- You should also use a hashing function (e.g. MD5) to improve security NOT done for this example
- Note: Formative observations are currently NOT recorded for data analytics – only exams

Log
attemptID (primary key)
timestamp (server time)
user (login details)
questions (random Q order)
answers (T/F)
time per question
mesh focus per question
direction {x,y,z - translation} 24x/s
magnitude {d – camera distance} 24x/s
Quarternion {x,y,z,w - rotation} 24x/s

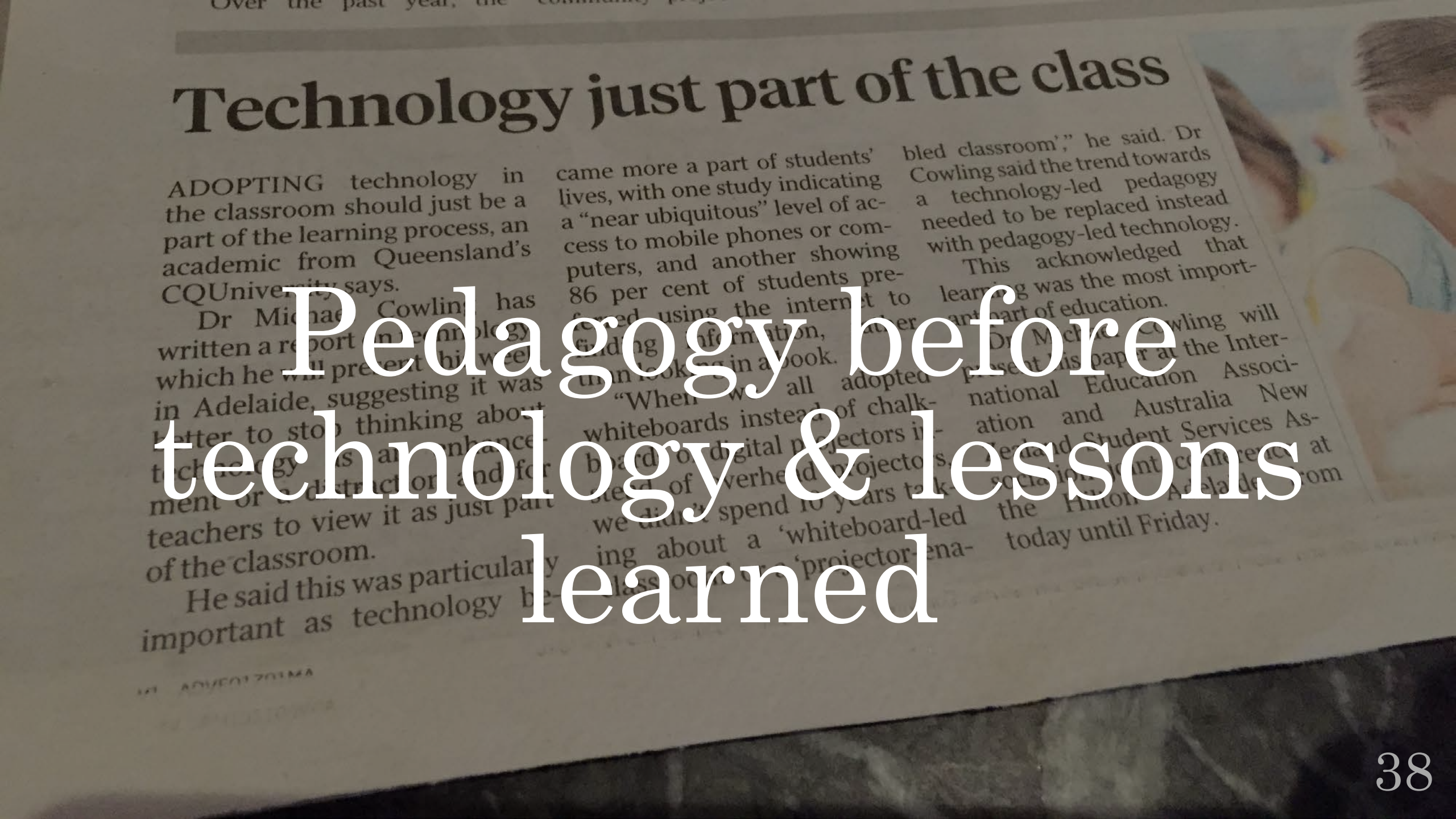
Great Tutorial on server side storage:
wiki.unity3d.com/index.php?title=Server_Side_Highscores

Dashboard

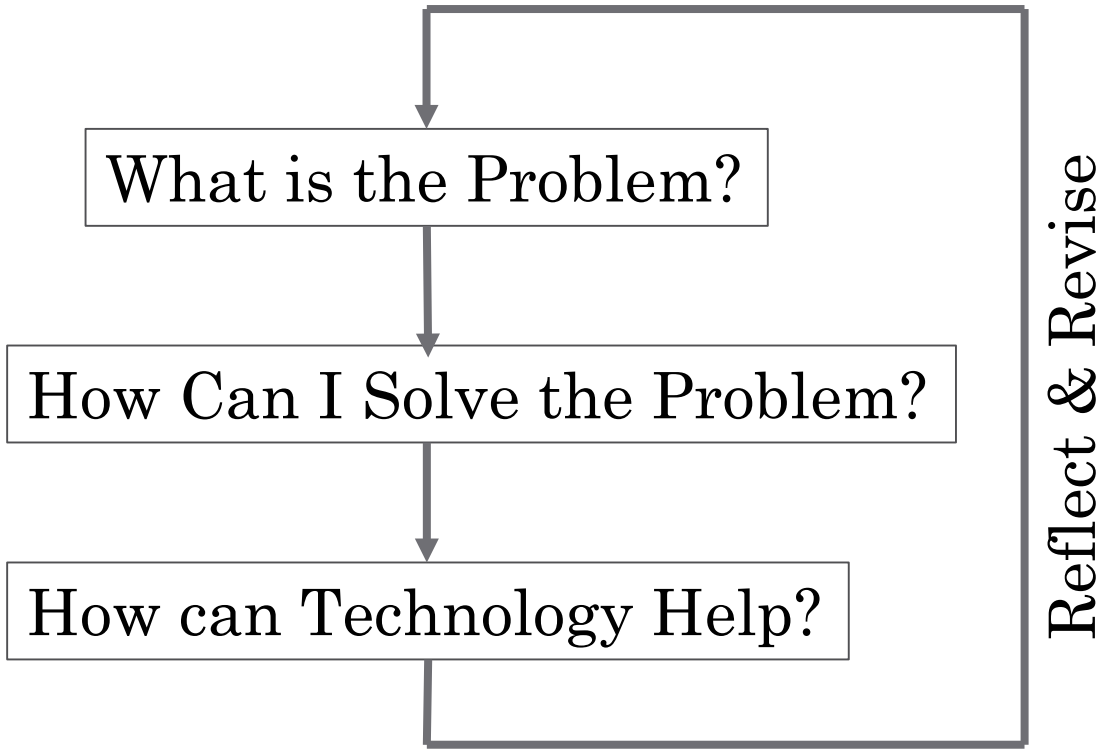
- At present the dashboard is a listing of all recorded actions from the SQL database using a php file
- The ultimate aim of the dashboard is to allow an [observer] to:
  - List all users that have/have not completed the simulation pedagogy
  - Check [learner] answers & method/time in answering
  - Search for a [learner] and [observe] (replay) their attempt using the recorded 3d spatial data [translation, distance and rotation]

Timestamp	User	Questions	Answer/Question	Time/Question	MeshSelected/Question
2016-11-17 07:48:22	12345	0,1,2,3,4,	F,F,F,F,F,	7.238323,5.628466,6.615757,6.550018,7.38278,	{LeftVentricle,},{LeftAtrium,},{LeftAtrium,},{PulmonaryTrunk,},{AorticArch,}
2016-11-17 08:03:56	98765	0,1,2,3,4,	F,T,F,F,F,	8.304294,12.31514,14.63738,8.455581,7.206904,	{LeftVentricle,},{PulmonaryTrunk,AorticArch,AscendingAorta,},{SuperiorVenaCava,RightVentricle,LeftAtrium,},{LeftCommonCarotidArtery,},{BrachiocephalicTrunk,}
2016-11-21 07:57:49	123456	0,1,2,3,4,	F,F,F,F,F,	8.632071,5.898353,17.11287,8.905243,8.231584,	{LeftVentricle,LeftAtrium,},{LeftAtrium,},{AorticArch,LeftAtrium,},{leftSubclavianArtery,},{BrachiocephalicTrunk,}
2016-11-21 10:23:36	1234567	0,1,2,3,4,	F,F,F,F,F,	7.009307,9.827247,6.01168,6.281147,6.727718,	{PulmonaryTrunk,},{leftSubclavianArtery,},{RightVentricle,},{LeftPulmonaryArtery,},{RightVentricle,}
2016-11-22 01:12:11	123456	0,1,2,3,4,	T,F,F,F,F,	27.87911,8.705873,20.59627,7.321079,8.006312,	{RightVentricle,RightAtrium,LeftPulmonaryVeins,},{RightVentricle,},{PulmonaryTrunk,LeftAtrium,},{AscendingAorta,},{LeftVentricle,}
2016-11-22 05:47:45	12345	0,1,2,3,4,	F,F,F,F,F,	12.61238,6.670756,7.058633,14.89314,6.949143,	{PulmonaryTrunk,RightVentricle,},{PulmonaryTrunk,},{RightAtrium,},{LeftVentricle,},{PulmonaryTrunk,}

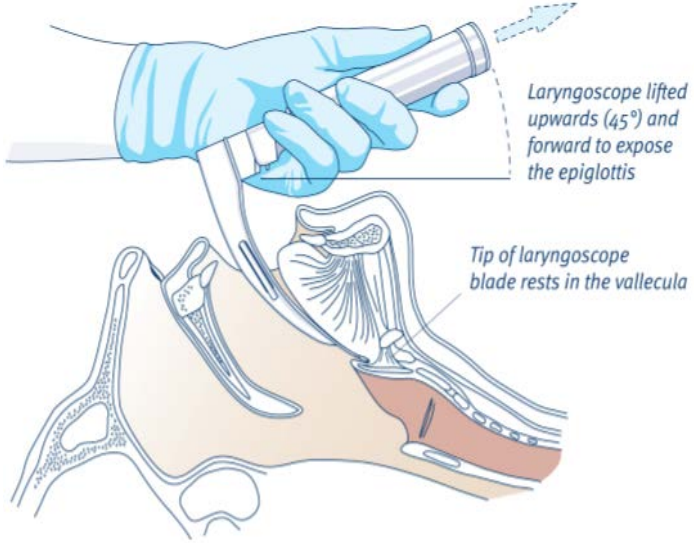
Pedagogy before technology & lessons learned



Pedagogy before technology



Paramedic Distance Education: The Problem



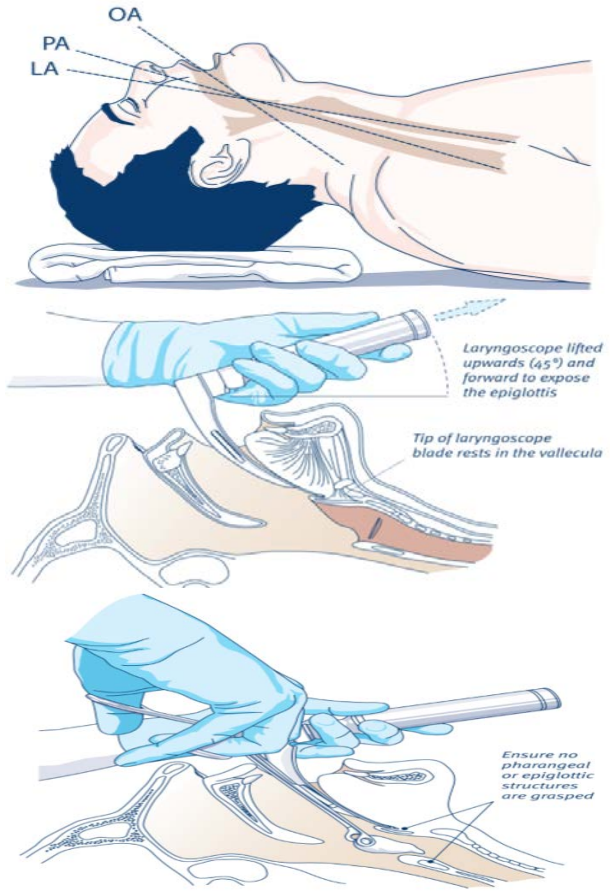
Traditional Teaching Method

"this course is a 'skills' learning course … there should be a way for us to actually get more time doing skills … distance students at a severe disadvantage … I am missing out … you can read about the skills but its impossible to get feedback and to know if you're doing it right … no substitution for experience … any software or equipment to at least go through the motions of doing the skills?" *Paramedic Student Learner(s) (201x-2014)*

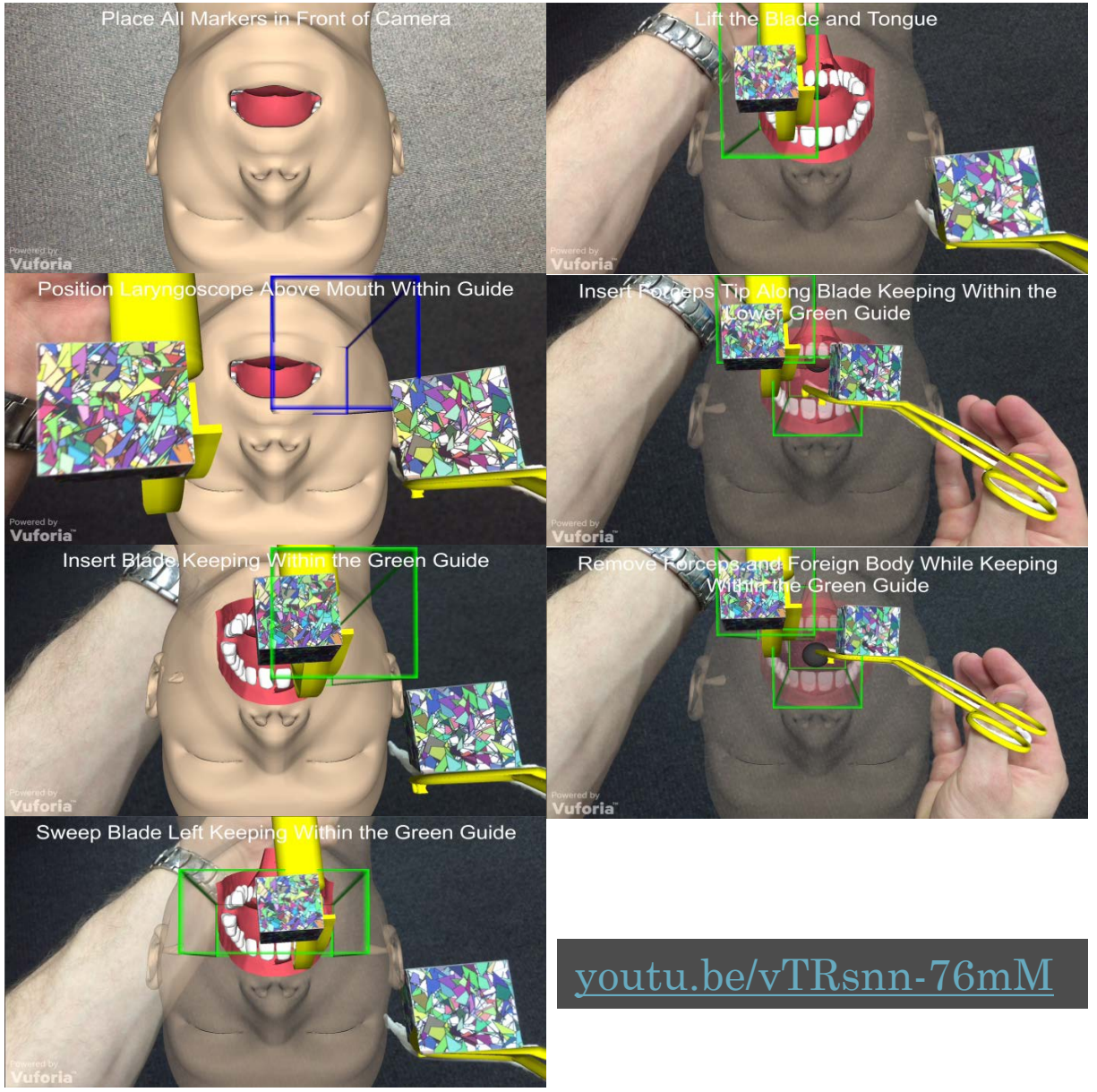
Paramedic Distance Education: Solving

- [Discipline expert] we need every student to have a portable airways mannequin & cheap tools to practice the skills - but cost is prohibitive … residential schools work … but not held early enough for students
- [Mixed Reality Team] tools could be provided to students by 3D printing them (cost/set) ~ $1 AUD + postage
- [Mixed Reality Team] Airways mannequin could be simulated virtually using a mobile phone
- [Discipline expert] students would need both hands free, so the phone would need to be mounted in their eyeline
- [Mixed Reality Team] we can provide a hat and 3d printed hat mount
- [Mixed Reality Team] A simulation app can then be constructed using a free game engine [Unity3d] that could observe and monitor [learner] skills

Paramedic Distance Education: Technology V1



Need to create a 1:1 mapping of the skills

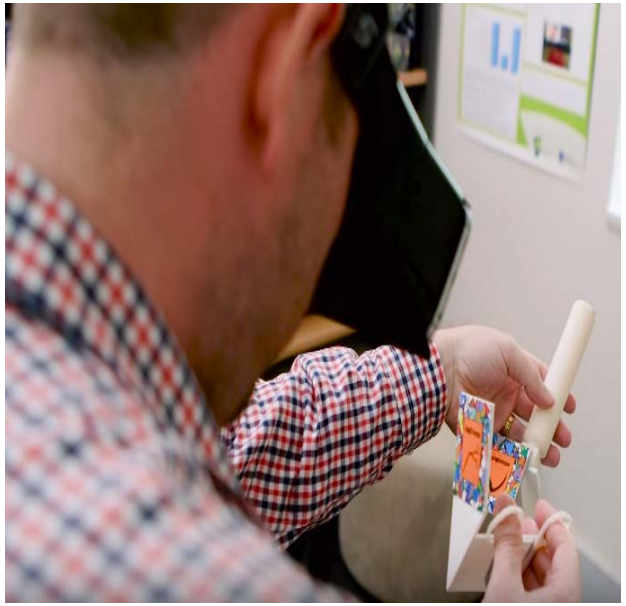


youtu.be/vTRsnn-76mM

Paramedic Distance Education: Reflection

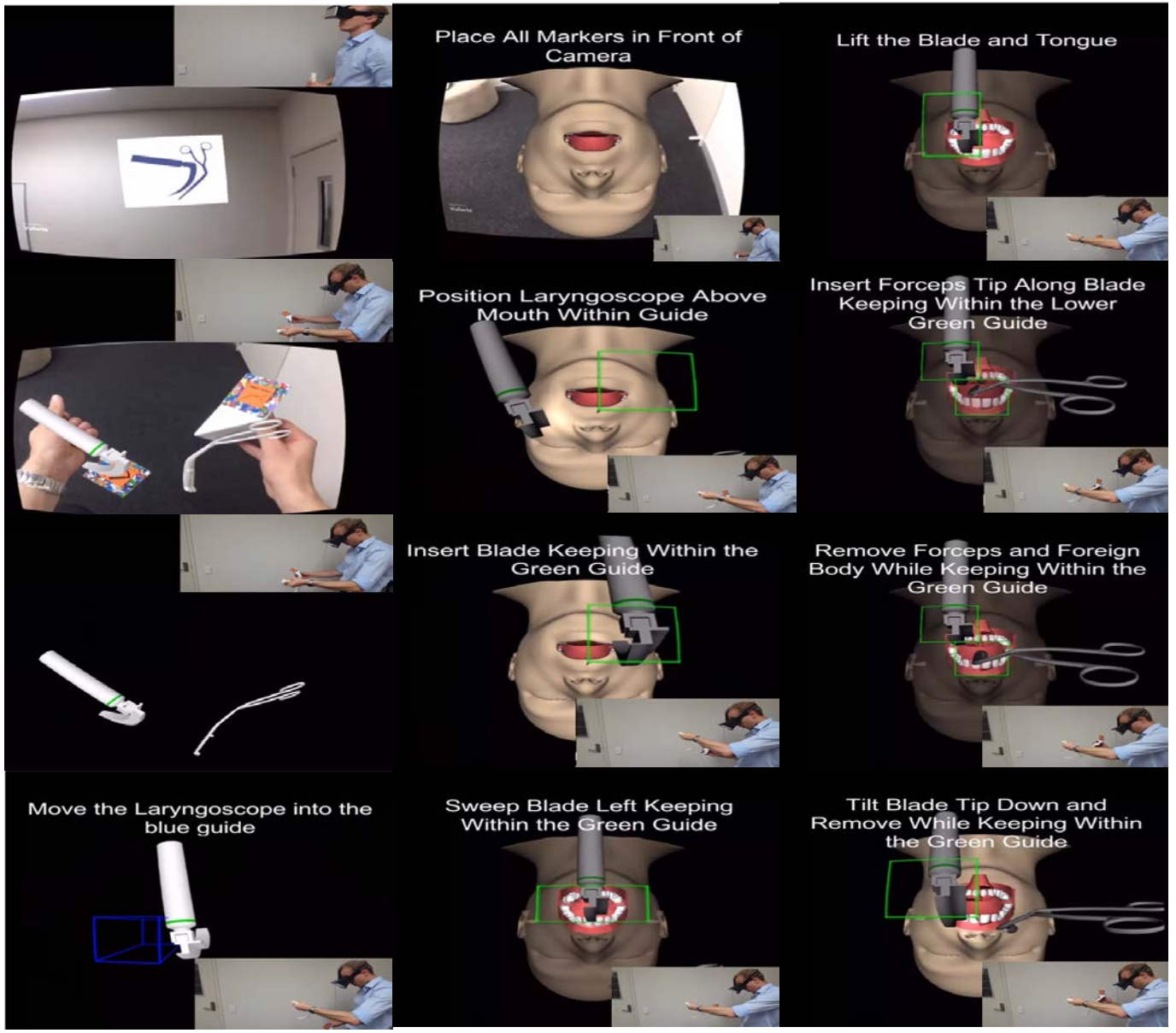
- [Learners] were very excited … [practice] the skills at home … [learner] more involved in the course & less isolated
- [Observers] found most [learners] struggled with the setup of the equipment & progression through the required steps … especially when introducing the Magill forceps & removing the foreign body
- [Learners] commented “my hands seem to pass by the [simulated airways manikin]” … “spent too much time focusing on the markers & not on the [simulated airways manikin] … resulting in frustration when the simulation would present red boxed & restart
- Many [learners] commented that they did not get around to using the [simulation] highlighting time struggles and being “extra” work
- [Head Paramedic] on reflection should have encouraged more frequent use of the simulation with a reminder & linkage to the learning tasks

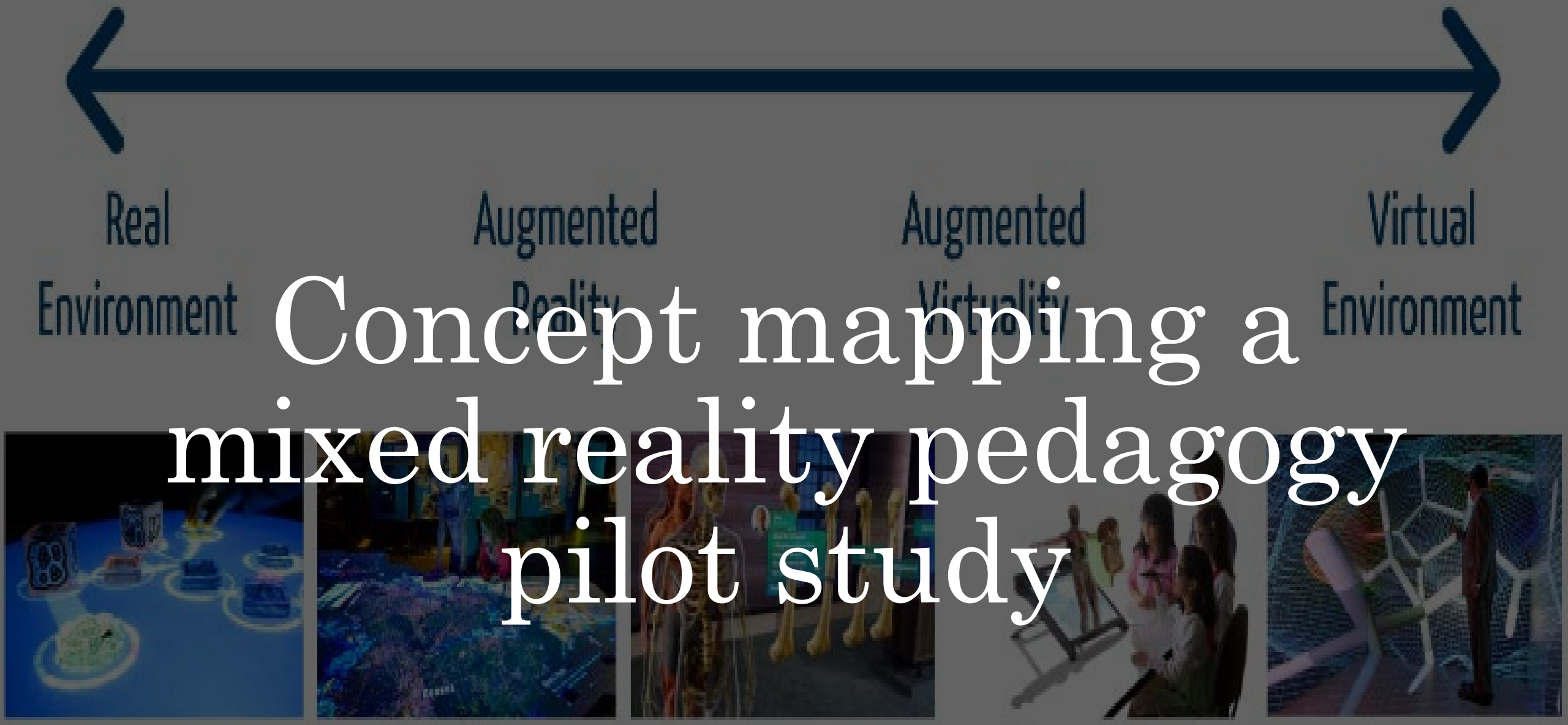
Paramedic Distance Education: Revision



youtu.be/wIfwZFKlSQU

Solve V1 issues but keep learning outcomes

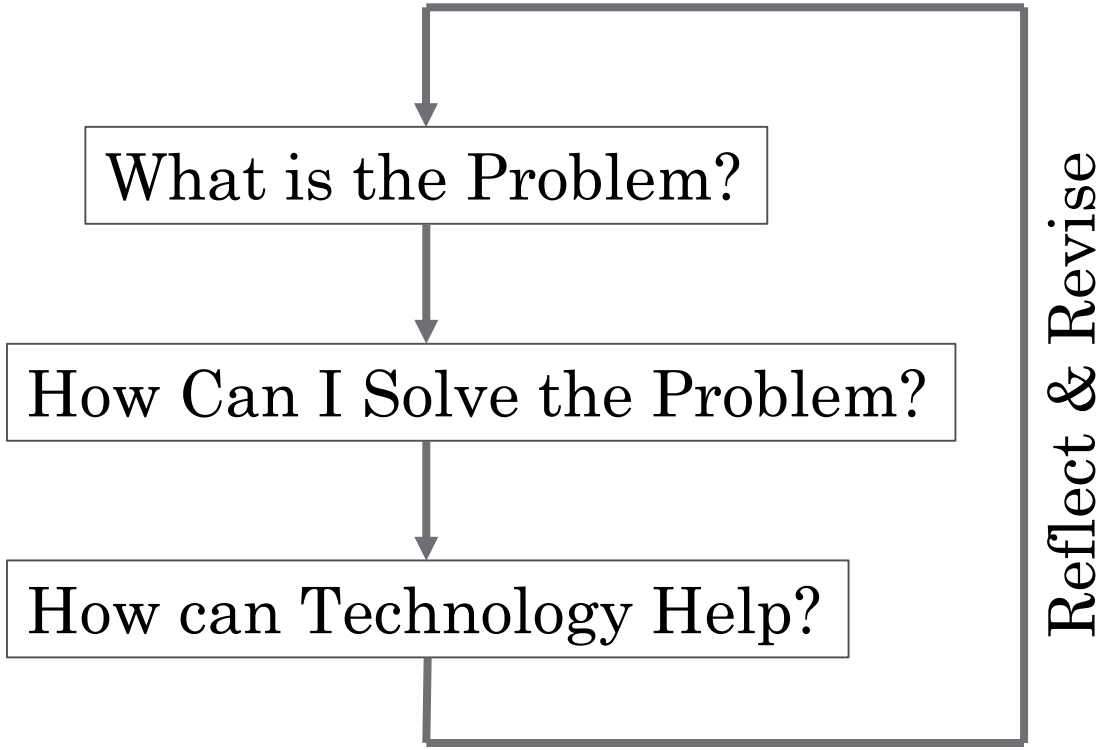




Concept mapping a mixed reality pedagogy pilot study

Let's Talk About You.

- How does this work for you in your classroom?
- Remember, PEDAGOGY before TECHNOLOGY



Let's Talk About You → What is the Problem?

- Start with your learning outcomes:
  - Which ones do students struggle with?
  - How do they struggle with them?
  - What do you think the problem is?
- Take 5 minutes to think of the most difficult problem students face in one of your classes, then we will ask a few people in the audience to share
- You can discuss with your table group if you'd like

Let's Talk About You → How Can I Solve the Problem?

- Pick a small problem to solve (can't solve the whole semester at once)
  - {Pretend you have a wand} → If [you] could do anything, what would help solve this problem?
- Take 5 minutes to write down the solution
- Remember there are no limits here, let your mind run free with whatever approach you think would best solve this problem you have
- Again, feel free to work with your table group on this

Let's Talk About You
→ How can Technology Help?

- Can you do that lesson right now? How would you do it?
- Could technology help with that lesson? → Think about the cases we presented
- Make sure you keep the purpose in mind, what is the lesson trying to teach, what do the students struggle with, and how does your method help with that outcome
- Take 5 minutes to come up with a solution that you think might work

Workshop Conclusion Survey

Mixed Reality in Higher Education: Pedagogy Before Technology - Workshop Feedback Survey

Presenters: Dr James Birt (Bond University) & Dr Michael A. Cowling (CQUniversity)

Thank you for participating. Your feedback on the experience, process and content is always appreciated.

QUESTIONS (Please cross the most appropriate response) - Likert Scale 1 - 5 - use (0) for N/A, (1) for strongly disagree and (5) for strongly agree						
Was the workshop content relevant?	0	1	2	3	4	5
Was the workshop content comprehensive?	0	1	2	3	4	5
Was the workshop content easy to understand?	0	1	2	3	4	5
Did you find the workshop well-paced?	0	1	2	3	4	5
Did you find the workshop engaging and interactive?	0	1	2	3	4	5
Did the workshop contain a good mix of listening and discussion?	0	1	2	3	4	5
Were the facilitators knowledgeable?	0	1	2	3	4	5
Were the facilitators well prepared?	0	1	2	3	4	5
Where the facilitators responsive to questions?	0	1	2	3	4	5
Did you find the activities useful learning experiences?	0	1	2	3	4	5
Overall how satisfied were you with this workshop?	0	1	2	3	4	5
Additional Comments						